# REPORTS OF GREAT BARRIER REEF COMMITTEE

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# The Physiography of the Bowen District and of the Northern Islands of the Cumberland Group (Whitsunday Passage).

By

G. A. V. STANLEY

Science Research Scholar 1925, University of Sydney, in conjunction with the Great Barrier Reef Committee.

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## THE PHYSIOGRAPHY OF THE BOWEN DISTRICT AND OF THE NORTHERN ISLANDS OF THE CUMBERLAND GROUP (WHITSUNDAY PASSAGE).

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### INTRODUCTION.

The question of the structure and origin of the existing coral reefs is still one of the major problems of modern geology. The brilliant simplicity of the Darwinian theory of subsidence has attracted a vast amount of support even to the present day, but at the same time several well-considered and powerful counter theories have been advanced in modern times.

Recent investigations have tended to lay stress on the fact that in most cases barrier reefs and atolls stand on the marginal areas of submarine banks or platforms, and the whole question of the growth

of reefs on these platforms has been discussed by T. Wayland Vaughan.[1] With regard to the origin of such platforms, R. A. Daly[2] accounts for them in terms of the Glacial-control theory, in which they are assumed to be of Pliocene age, while the existing reefs are all post-Glacial.

Now that W. M. Davis has pointed out that the coral reefs themselves—interesting as they are to the biologist—can tell the geologist scarcely anything as to their origin, geological interest has been transferred from the living structures to the basement platforms on which they rest. It is to these platforms that attention must be directed in the search for evidence of recent crustal movements which have controlled the building of the existing coral reefs.

It is only from a complete study of the continental coastline and the physiographic features of the islands of continental rock which lie between it and the Great Barrier Reef, that an adequate understanding of the building of the Great Reef can be obtained. When the warping and faulting movements, which have clearly exercised an important control on its growth are better understood, then reasonable estimates of the probable thickness and the geological age of the Reef can be made.

Along the Queensland coast between the latitudes of Gladstone (24° S.) and Bowen (20° S.), a distance of about 250 miles, the area between the Barrier Reef complex and the coast is littered with festoons of high, rocky islands. The islands of Keppel Bay, near Rockhampton, have been described by F. Jardine,[3] but beyond this the festoon islands, which certainly attain a better development further north, have not been studied in detail. They have, of course, been commented on by numerous observers, and attempts have been made to explain their origin. In 1916, W. M. Davis[4] visited Queensland in the course of a world-wide survey of coral reefs and their problems. Realising the significance of the festoon islands in elucidating the problems connected with the Reef, the great scientist in the report of his investigations published a reproduction of portion of Admiralty Chart 347, embracing the Whitsunday Islands, and added two sketches of the islands and one of the mainland in the vicinity of the Whitsunday Passage. A recognised champion of the Darwin–Dana hypothesis, he clearly regarded this area as one of the most significant along the whole coastline.

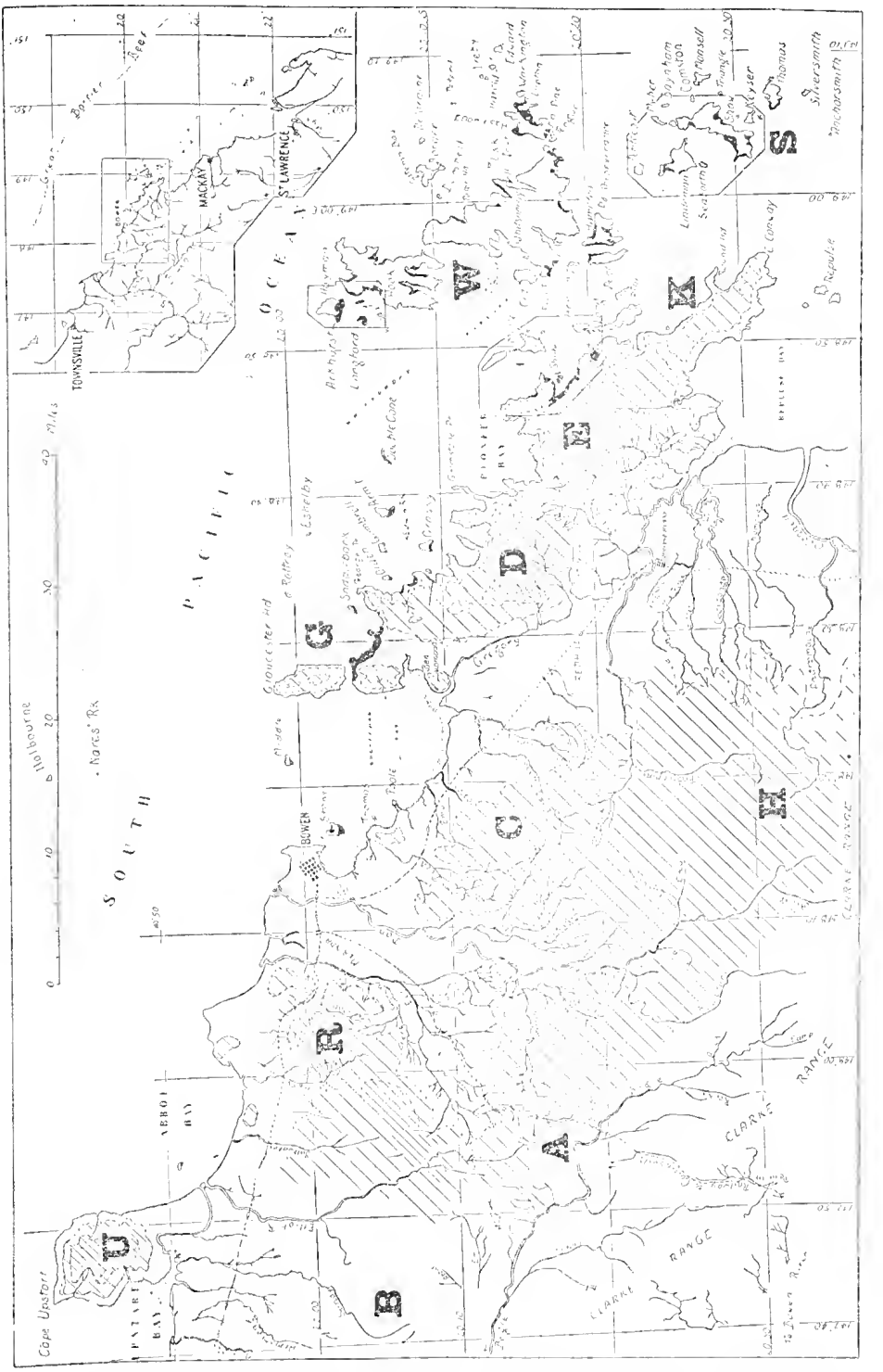
In the following paper it is proposed to describe the physiography of the island festoons in the vicinity of the Whitsunday Passage, as well as that of the mainland coastal area lying between the towns of Bowen and Proserpine. The extent of the field under investigation is indicated in Text-fig. 1. Here is the most northerly development of well-defined

[1] T. W. Vaughan: Bulletin 103, U.S. National Museum, 1919.

[2] R. A. Daly: Various papers dealing with the Glacial-control theory.

[3] F. Jardine: "The Physiography of the Port Curtis District." Trans. Roy. Geog. Soc. A'sia. (Qld.), Vol. 1, 1925, pp. 83-86.

[4] W. M. Davis: "The Great Barrier Reef of Australia." American Journal of Science, Nov., 1917.




Text-fig. 1.—An Index Map, showing the area investigated. The topography is suggested by form-lines. Areas shaded are over 500 feet high; *in places* closer shading indicates areas over 1,500 feet high. The islands, though high, have been left unshaded. Railways are shown by broken lines. Fringing coral reefs are shown black. Three polygons indicate the areas shown in block diagrams.

island ares, and its detailed description is to be regarded as a preliminary to the examination of the very much larger number of island chains stretching as far south as Keppel Bay, and embracing the remainder of the Cumberland Islands as well as the islands of the Northumberland Group. The complete investigation of these will be undertaken during 1926.

It is hoped that the present paper will serve as a solid basis for inductive reasoning of the type so skilfully employed by W. M. Davis.

## PREVIOUS LITERATURE AND ACKNOWLEDGMENTS.

In a general way the area has been described by most of the early explorers and investigators who visited the north-east coast of Australia. Accounts are contained in the journals of Cook, Flinders, King, Stokes, Jukes, MacGillivray, and others.

After the discovery of Port Denison by Sinclair in 1859 we must look to G. E. Dalrymple's reports to the Government of the infant State of Queensland for information. The history of the early development of the district is to be found in local records.

Of later years, references to the area are contained in the writings of Agassiz, Coppinger, E. C. Andrews, W. M. Davis, H. C. Richards, Chas. Hedley, and W. H. Bryan.

Accounts of the geology of the mainland appear in reports by R. Daintree, R. L. Jack, Robt. Etheridge, junr., A. Gibb Maitland, E. C. Saint Smith, B. Dunstan, Dr. Jensen, J. H. Reid, and C. C. Morton.

Acknowledgments are made of courtesy and valuable assistance of various kinds reeeived from residents of Bowen, too numerous to particularise.

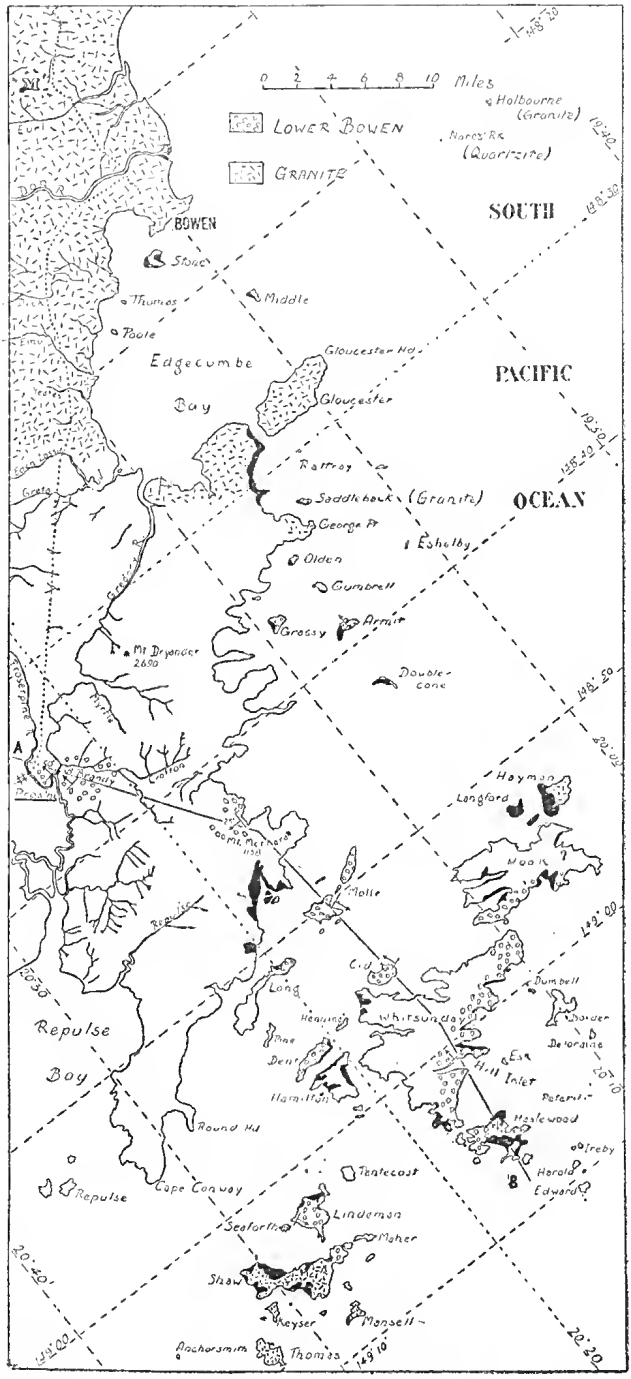
By arrangement with the Naval Board and by courtesy of Capt. J. A. Edgell, O.B.E., R.N., the writer was permitted late in the year (1925) to join H.M.A.S. "Moresby." It was only through the unique opportunities thus afforded that much of the detailed information contained in the following report was obtained.

The writer also wishes to aeknowledge the assistance of the Great Barrier Reef Committee, which afforded transport faeilities and other generous assistance.

## GEOLOGICAL OUTLINE.

The geology of this area is not well known. As field work progressed it became increasingly evident that the scope of the work, at first only physiographie, would have to be extended to include a study of the geological details of the localities being investigated. These details are presented in the body of the report. At this stage it is sufficient to give merely a summary of the salient characters of the geology.

Between Cairns and Mackay, granite bathyliths are well developed. Charters Towers, Ravenswood, and Bowen are all situated on one of




Text-fig. 2.—Geological Sketch Map.

these gigantic masses, and the core of the Clarke Range is largely granitic. It has been shown by Morton[5] that large areas of basic plutonic rocks are associated with the granites, and that these range from diorites to hornblende gabbros.

To the west of the Clarke Range, in the latitude of the area under discussion, lies the Bowen River coal-field. (See Text-figs. 1 and 3.) This area has been clearly reported upon by J. H. Reid,[6] who shows that the Permo-Carboniferous rocks lie in the form of a syncline on basement rocks of granite and metamorphics.

Of these Permo-Carboniferous rocks, the Lower Bowen consists chiefly of volcanics; the Middle Bowen is a marine series, with the coal beds beneath; the Upper Bowen is chiefly a fresh-water series with one marine horizon.

Some of the northern islands of the Cumberland Group are granitic. Many, however, are composed of tilted and folded volcanic rocks. These are chiefly andesites, basalts, tuffs, and coarse agglomerates. They are considered by the writer to be of Permo-Carboniferous (Lower Bowen) age. So far, palæontological support is lacking.

The extent of the volcanic rocks is indicated in the geological sketch map, Text-fig. 2.

## DETAILED PHYSIOGRAPHY.

The eastern coast of the Australian continent is a variety of the Pacific type of coast, to use Suess' term, in which the mountains and the trend of the rocks are parallel to the shore.

Reference to Text-figs. 1 and 3 will show the salient physiographic features of the area under discussion. These may be briefly described as follows:—

(*a*) *Island festoons.*—These consist of several arcs or festoons of high, rocky islands trending sub-parallel to the mainland, from which they are separated by the Whitsunday Passage. All the shorelines are embayed; hence the islands are to be regarded as parts of a long chain which has been disarticulated by drowning. Plunging spurs and cliffs are well developed. The festoons are lettered W, S, in the figures.

(*b*) *Coastal Ranges.*—(Lettered K, E, D, G, in the diagrams.) The coast ranges are linear and very lofty. They trend from Cape Conway to Gloucester Head, and are broken into several blocks by transverse gaps.

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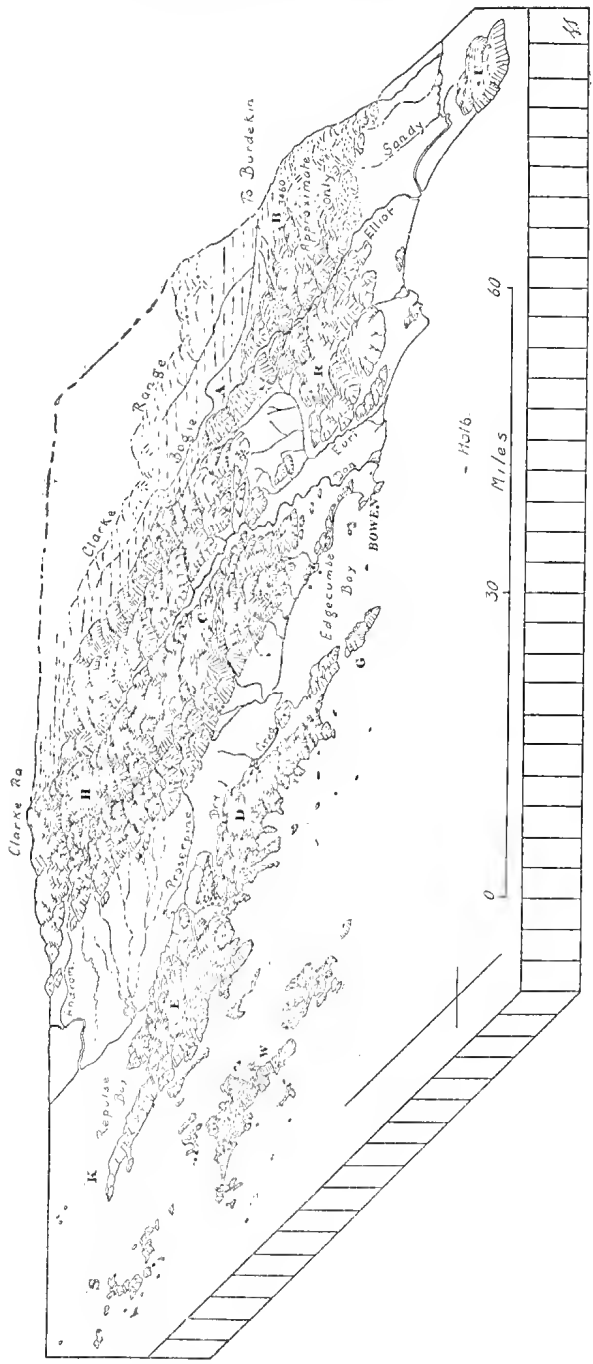
[5] C. C. Morton: "The Normanby Goldfield. Report on the Southern Portion." Part 2, Qld. Govt. Min. Jour., Vol. XXI., 1920, p. 322 *et seq.*

[6] J. H. Reid: "Geology of the Bowen River Coalfield." Qld. Govt. Min. Jour., Vol. XXV., 1924.




Text-fig. 3.—A Block Diagram, showing the salient features of the area investigated. The figure is lettered to correspond with Text-fig. 1. (A) Mt. Aberdeen mass; (B) Mt. Abbott mass; (C) Challenger mass; (D) Dryander mass; (E) Conway Range; (G) Gloucester mass; (H) Composite mass near Mt. Hector; (K) Ranges near Cape Conway; (W, S) Main, or Whitsunday-Shaw Island festoon.

(*c*) A "Corridor," or lowland area stretches between Repulse and Edgecumbe Bays. This is trough-like in character. On its western side it is bounded by—

(*d*) The dissected margin of the western "plateau." (Lettered H, C, R, U, B, A, in the figures.)

It is proposed to describe each of these sections in considerable detail, and then to examine the conclusions to which the detailed study leads.

### The Island Festoons.

The Whitsunday Passage is justly famous for the beauty of its scenery. From the tourist point of view the bright little booklet compiled by the Queensland Government Intelligence and Tourist Bureau, entitled "The Bowen District and the Whitsunday Passage," may be consulted.

For maps of the area, Admiralty Charts 2763, 347, 348, 498, 1125, and 2803 are available. The general charts of the area (347 and 348) are due for revision. They are drawn to such a scale (about 4 miles to the inch) that they are of little assistance to the physiographer seeking details of the submarine contour of the islands. There is good reason to believe that when the area is resurveyed some striking and important revisions will be made, especially in the delineation of the submerged portions of island trend lines.

In Text-fig. 25, the bathymetry and the trend lines of the island festoons are indicated.

#### *The Outer or Easternmost Festoon.*

This consists of a festoon of small islands which closely resemble each other, trending N.W. and S.E. The islands rise from a broad submarine floor about 26 to 30 fathoms in depth. The chain is about 10 miles long.

*Deloraine Island.*—This island is irregular in shape, and rises to a height of something like 200 feet. Its charted height (114 feet) is too low.

It is composed of rocks which are pinkish in colour, and which are undoubtedly agglomerates. Opportunity was not afforded of landing here.

The eastern side is well cliffed. Plunging cliffs rise straight out of deep water to about 180 feet. (See Text-fig. 4.) The marine erosion

Text-fig. 4.—Sketch of Deloraine Island from the eastward. Note the development of plunging cliffs and the flat area at the north end.

has outstripped the sub-aerial denudation, for on this eastern side the small gullies form hanging valleys above the cliffs. At the northern end is a low vegetated flat, which is possibly a sign of recent elevation of small amount. Fringing coral reefs are absent.

*Peteril Rocks.*—These are small rocky remnants which have been subjected to severe marine erosion. Their height is a good deal greater than charted (20 feet).

*Ireby Island.*—This island is formed of dark-coloured rocks, and is charted as 164 feet high. The rocks are undoubtedly volcanic. It is well cliffed on all sides, the cliffs reaching almost to the summit. Nearby is an unnamed rocky island, charted as 111 feet high.

*Harold Island.*—This is one of the largest islands of the chain, and is charted as 247 feet high.

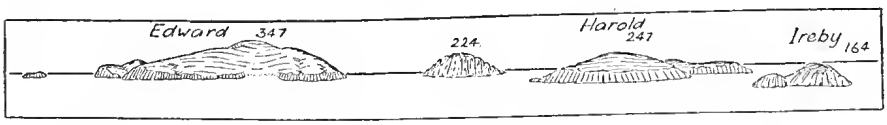
It is formed of dark-coloured volcanic rocks.

Plunging cliffs are developed all round, and these are higher on the eastern and south-eastern sides. There is a distinct beach developed around the island. This just covers at high water. Possibly is represents a slight elevation, because it is doubtful if it could have been formed in its present position. Fringing reefs are absent. To the east is a small rocky island, 224 feet high, which is cliffed right up to its summit.

*Edward Island.*—This is the largest and highest island of the group. It rises to 347 feet.

Geologically it is composed of volcanic rocks—breccias and basaltic lavas—which strike N. 20° W. and dip very steeply to the eastward. A well-developed series of vertical joints runs N. 50° W.[7]

The island is dissected by steep consequent gullies, but is not deeply embayed. Cliffs are well developed on all sides, especially on the east.




Text-fig. 5.—Sketch of the islands of the easternmost festoon from the northward. Note the plunging cliffs.

On the western or more sheltered side there are in places traces of a beach of marine erosion which just covers at high water. This seems to be suffering erosion, and so may be regarded as evidence of a slight elevation. The beaches are formed of coral shingle, although no fringing reefs are developed.

See Text-fig. 5.

### *The Margin of the Main Festoon.*

The eastern margin of the main Hook–Whitsunday festoon may be considered to be defined by the 17-fathom line. (See Text-fig. 25B.) This line encloses some rather ill-defined festoons, which consist of Border and Haslewood Islands, with which are grouped for convenience Dumbell, Esk, Teague, Pine, Lupton, and Workington Islands. (Refer to Text-fig. 1.)

*Border Island* is triangular in shape and is a little over 2 miles long. At the north end, Mosstrooper Peak reaches a height of 747 feet.

[7] All bearings given are magnetic. The variation is about 7 deg. East.

Geologically the island is formed of rocks of the volcanic series, but the details are unknown.

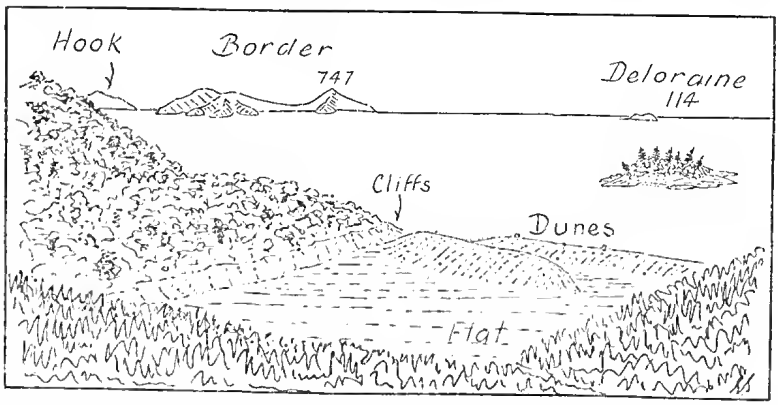
The shoreline is well embayed, and in the bays some inextensive fringing reefs are developed. Plunging cliffs are developed chiefly along the eastern side.

Cateran Bay is separated from the eastern side by a low neck about 150 feet high. Some of these features are represented in Text-fig. 6.

*Haslewood Island.*—This is the largest of a group consisting of Teague (285 feet), Pine (356 feet), Lupton (445 feet), and Workington (320 feet). It rises to over 650 feet in the south-eastern corner.

Geologically the island is composed of tuffs and agglomerates, which strike N. 30° E., and dip very steeply to the south-eastward.

The island is deeply embayed, the embayments apparently being controlled by rock strike, which here chances to approximate to a direction at right angles to the trend lines. The embayments are either silted up or closed by coral reefs. Fringing reefs are extensively developed. Lupton Island is tied to Haslewood by a reef. Along its north-western aspect the island is somewhat cliffed. Sometimes these cliffs are really joint planes which have been bared by the action of the sea. They are now removed from the present attack of the sea, and in places they are covered with grasses and shrubs. The pebbly, shingle beaches at their foot barely cover at high tides. These facts are taken to indicate an uplift of a few feet above the present high-tide level.




Text-fig. 6.—Sketch from Haslewood Island looking northward, showing Border and Deloraine Islands in the distance. The small pine-clad islet is connected to the main island by a fine fringing coral-reef. Note the small bluffs around it. The bay in the foreground has been silted up. Note the cliffs extending behind the dunes.

Again, as indicated in Text-fig. 6, the cliffs extend into the silted-up embayments. The sandy flat in the bay sketched is but a few feet above sea-level, and sand dunes separate it from the sea. In the sketch, note the extent of the cliffing of the little pine-clad, rocky island which is connected to the main island by a fringing reef.

In other places white sandy beaches and dunes are developed

bordering sandy, grassed flats some few feet above sea-level, in a manner exactly similar to that described by Andrews[8] from Dunk Island.

Haslewood Island is occupied by sheep-farmers—Messrs. Polgleaze and Pougher. It is grassed, and timbered with tea-trees and eucalypts.

Pallion Point is the termination of a hilly area, which is connected to the rest of the island by a low sandy neck.

Workington Island is well cliffed all along its eastern side. Its summit is pine-clad.

*Dumbell Island* is 182 feet high, and lies in mid-channel between Border and Whitsunday Islands.

The details of its geology are unknown, but it is certainly composed of volcanic rocks, probably coarse clastics and lavas.

Physiographically the island is of interest, because it has been sculptured on all sides into small cliffs, and shows around its margin a small wave-cut notch, which is now raised about 4 feet above high-tide level. At its eastern end is a peculiar domed, rocky hill, which, like so many of the islands in the area, is pine-clad.

*Esk Island.*—This islet lies at the north end of a sandy bank (known in the Admiralty publications as French Shoal) which stretches about 3½ miles to the south-eastward into Whitehaven Bay.

Its geology is unknown, but it is probably similar to Haslewood and Whitsunday Islands.

The island is a little over 100 feet high, is pine-clad, and is eroded by the waves into small cliffs and sandy coves.

### *The Main Festoon.*

This is one of the most important physiographic features of the area. It is continued far to the south, through the islands of the Northumberland Group and so to the *coral* islets (atolls) of the Capricorn and Bunker Groups.

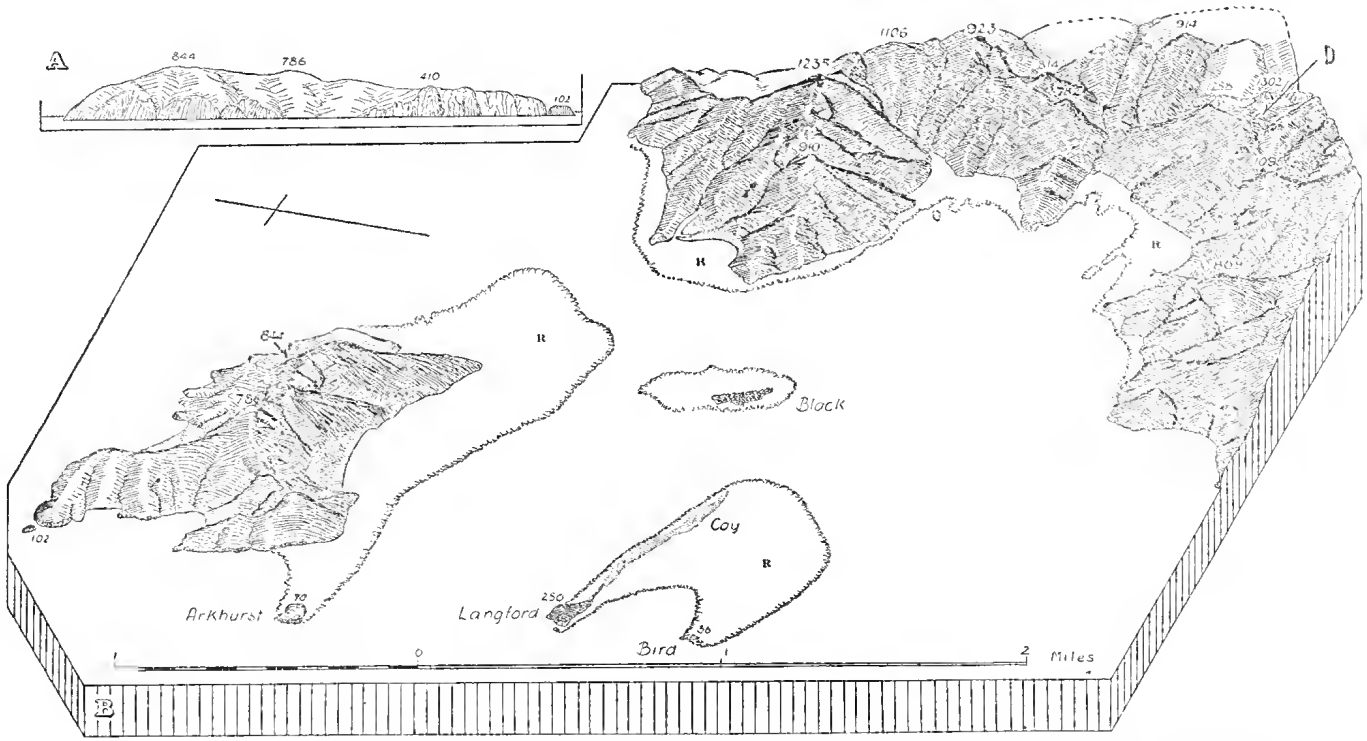
In the area under consideration it comprises such huge mountainous masses as Hook and Whitsunday Islands, as well as more than twenty other large rocky islands. Seen from a distance it is singularly flat-topped and wall-like. See Text-fig. 17.

It is proposed to describe the salient features of each of these islands, commencing at the northern end.

Throughout the descriptions, refer to Text-figs. 1 and 3.

*Hayman Island.*—This is the northernmost of the Cumberland Islands. It is 844 feet high.

[8] E. C. Andrews: "A Preliminary Note on the Geology of the Queensland Coast, with reference to the Geography of the Queensland and New South Wales Plateaux." Proc. Linn. Soc. N.S.W., Vol. xxvii., 1902.




Text-fig. 7.—(A) Sketch of Hayman Island from the north-eastward, showing development of plunging cliffs and mature topography. (B) Block Diagram of Stone Haven. Note the large development of fringing reefs (*R*) and the absence of extensive cliffs. At *D* is shown a relic of a mature, upland topography.

Geologically it is composed of a fairly homogeneous pink granite, which, particularly on the eastern side of the island, is intersected by small basic dykes.

In profile the island is rounded. It is dissected by numerous small consequent gullies, and is embayed, but not very deeply. Plunging cliffs, over 250 feet high, are developed along the eastern side. (See Text-fig. 7, A.) These face water with depths of over 20 fathoms. At the north end a large vertical joint has been attacked by the sea, with the result that a small rocky islet, 100 feet high, has been formed.

On the western and southern sides is an extensive fringing reef. This reef joins Hayman Island to Arkhurst Island (70 feet). In one place behind it there is an extensive sandy, grassed flat, covered with low scrub.

There is no sign of recent uplift on this island.

*Langford Island* is about half a mile long and is 250 feet high.

Its geological nature is unknown, but it appears to be formed of volcanic rocks.

A large crescentic fringing reef extends to the south and south-east for about a mile. At the southern end of this is a small rocky islet[9] 36 feet high.

Langford Island is of considerable interest because it was visited in 1896 by Alexander Agassiz, who claimed that it supported his views as to the origin of the Great Barrier Reef. He writes:—

> "The reef flat . . . is undoubtedly underlain by the extension of the rocky platform of Langford Island, part of which crops out as the rocky islet . . . the rest of the foundations having been worn away by atmospheric agencies above the water-line and by the action of the sea below that line."[10]

To the writer this view does not seem to be correct. The island is cliffed only on the north, where it is not fronted by the reef. If it had been disarticulated from Bird Island by marine erosion, in a manner similar to the separation of the rocky islet at the north end of Hayman Island (mentioned above), it should have been well cliffed on all sides, since a great deal of active marine erosion is implied by Agassiz' claim.

It is considered that Langford and Bird Islands have been separated merely by drowning, and that the coral reef has reunited them only owing to their proximity.

At low tide a small sand cay bares on the reef flat to the east of the island. (See Text-fig. 7.)

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[9] This rocky islet has recently (Sept., 1926) been named Bird Island, by Capt. Edgell, O.B.E., R.N.

[10] A. Agassiz: "A Visit to the Great Barrier Reef of Australia in the steamer 'Croydon' during April and May, 1896." Bull. Mus. Comp. Zool., Harvard. Vol. XXVIII., No. 4, 1898.

*Black Island,*[11] to the east of Langford, is low and densely wooded. An extensive fringing reef has formed on the eastern side. The beach around the island is covered with large slabs of recent beach conglomerate, containing pebbles of volcanic rocks and rounded fragments of coral.

Agassiz visited this island, too, for he writes:—

> "On Woody Island, a small islet to the east of Langford Island, the corals have similarly grown upon the slopes of the flat which surrounds the island, but the greater part of the island has been washed away, as has been Langford Island."[12]

The bay enclosed between Hayman, Hook, and Langford Islands has been recently (Sept.-Nov., 1926) surveyed by Capt. Edgell and the officers of H.M.A.S. "Moresby," and has been named Stone Haven. (Text-fig. 7.)

Text-fig. 8.—Sketch of the northern side and north-eastern end of Hook Island, showing the degree of dissection and the development of plunging cliffs. Compared to the mature topography the cliffing is only incipient.

*Hook Island.*—This island is about 8 miles long and 4 miles broad. It is the first of the large mountainous islands to be described. So large is it that it is impossible to give all the details of its physiography. Below are set out the salient features, together with details of small portions which were closely examined.

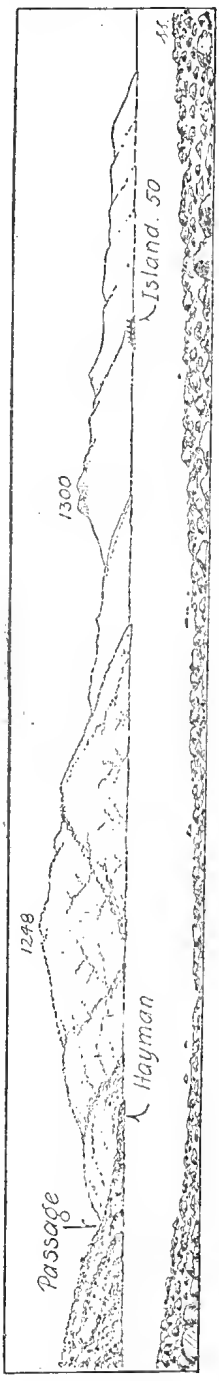
So far as could be made out, the island consists entirely of volcanic rocks—agglomerates and lavas. This is true for the whole of the eastern and northern sides, as well as for Stone Haven on the western side. It is only at the latter locality that the rocks were examined in detail. There they strike N. 15° W., and dip to the westward at angles of 40°–60°. Rocky Hill (1,302 feet high) is formed of volcanic materials from top to bottom. These are chiefly massive, coarse agglomerates.

The island is high and rugged. Hook Peak, in the north, is 1,478 feet high. Other peaks shown on the Admiralty Chart are 1,248 feet, 1,302 feet (Rocky Hill), and 986 feet. The dissection is elaborate and profound. In consequence the island is deeply embayed. This is so especially in the south, where two parallel inlets penetrate the island for about 3 miles.

The gullies which enter Stone Haven are in most cases steep-sided and youthful. (See Text-fig. 7.) In the case of several of the longer creeks there is a sharp change in gradient at a point some hundreds of

[11] So named by Capt. Edgell, Sept., 1926.
[12] A. Agassiz: Op. cit.

feet above sea-level. Above this point the valleys assume a more mature character. From the summit of Rocky Hill one can look over a small relic of this maturer, upland topography, which is being attacked on all sides by torrential, consequent gullies. Does this represent a relic of the Pliocene topography? (At D, in Text-fig. 7, B.)




Text-fig. 9.—Sketch of the north-western side of Hook Island from Hayman Island. Between the foreground and the far end of Hayman Island is a fine fringing reef which nearly joins the reefs along the shores of Hook Island. The pine-clad island (Woody Island) is surrounded by an extensive reef. On Hook Island Rocky Hill is 1,300 feet high.

The northern and eastern sides of the island are well dissected and deeply embayed. The headlands are all truncated by plunging, spur-end cliffs, which at the north-eastern point of the island, near Pinnacle Rocks, attain a height of 270 feet. These descend into depths of 17 to 20 fathoms. (See Text-fig. 9.)

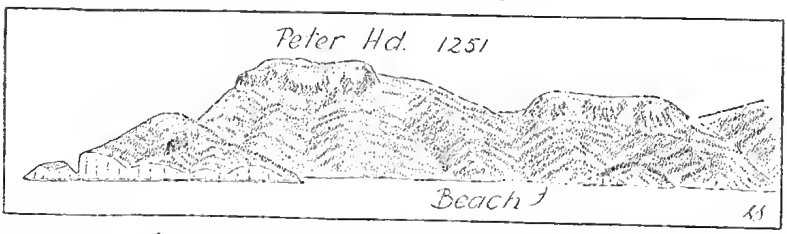
Fringing reefs are very irregularly developed. They are invariably absent along those parts of the coastline which face deep water. On the contrary they are always present in deep bays, or where, as at Stone Haven, the submarine profile is gentle. This is opposed to the opinions generally current that the reefs tend first to colonise the rocky headlands, being prevented from growing in the embayments owing to the quantities of silt which are deposited there. The two long *rias* at the south end of the island are both enormously silted up. In each of them are depths of only 3 to 4 fathoms, while on either side the hills rise steeply to nearly 1,000 feet. Yet in each are developed fringing reefs, which become broader towards the head of the embayment. In Stone Haven, fringing reefs are well developed. (See Text-fig. 7.)

The western side of the island is sub-parallel to the eastern side. It is not so well cliffed, but in places rocky bluffs are developed along spur-ends, attaining a height of 50 feet. This is chiefly true for about 2 miles north of the south-west point. In Stone Haven only insignificant rocky bluffs are present. (See the sketch from Hayman Island, Text-fig. 8.)

*Whitsunday Island.*—This is the largest of the Cumberland Islands. It is about 12 miles long in a N.-S. line, and about 10 miles broad at its widest part (almost E.-W.) in the south. Like Hook Island, this island is rugged and inaccessible. Whitsunday Peak, on the west side, rises

to 1,426 feet. Other peaks are the Cairn (1,230 feet), 1,200 feet, 1,251 feet, Whitsunday Craig (1,175 feet), &c.

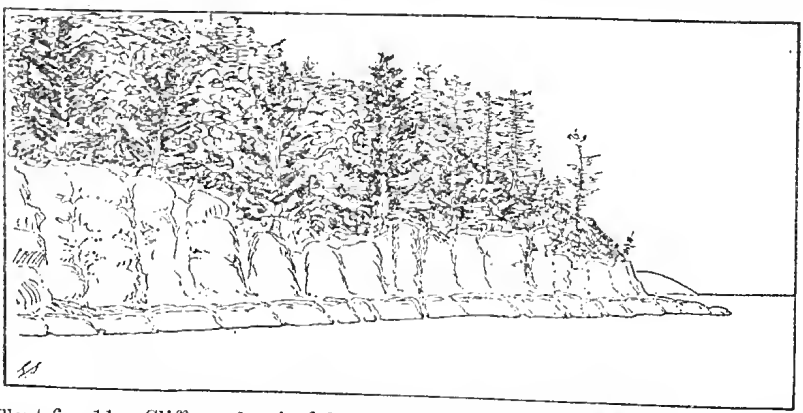
As far as is known, the island is composed only of rocks of the volcanic series. These comprise various kinds of agglomerates, tuffs, and lavas. At Hill Inlet, in the south-west portion of the island, the rocks were examined in detail. They comprise medium and fine-grained agglomerates, together with an intercalated flow of trachy-andesite. The series has a uniform strike of N. 5° W.: at the eastern end of the section they dip at 65° to the westward, while further to the west the dip lessens to 20°. Whitsunday Peak, which was climbed, consists of volcanics from top to bottom. These strike about N. 15° W. and dip steeply to the westward. The structure appears to be that of an anticlinal limb dipping to the westward, and as such it has been represented in the geological sketch section. See Text-fig. 24.




Text-fig. 10.—Sketch of Peter Head, east side of Whitsunday Island. Owing to being sketched from a cutter, the embayments are foreshortened. Note the cliffs on the headlands and the raised bench at their base. Note, too, the rounded cliffs on the hills, characteristic of the weathering of the agglomerates.

Again, like Hook Island, the dissection of the island is deep and well advanced. Great gullies lead from the head of deep embayments, such as Hill Inlet and Gulnare Inlet. In the case of the former the island is all but truncated by the length of the gorge.

The eastern side of the island is, in the north, high and rugged. Huge rounded masses and domes of bare rock form the unscaleable hill-



Text-fig. 11.—Cliffs and raised bench, 4 feet above H.W.M., Whitsunday Island, near the north end. Note the prominent joints in the cliffs. The rocks are massive agglomerates.

sides, and round tumbled boulders fringe the waterline. Plunging cliffs are developed in places on the headlands, such as Peter Head. (See Text-fig. 10.) Embayments are well developed. Along most of this

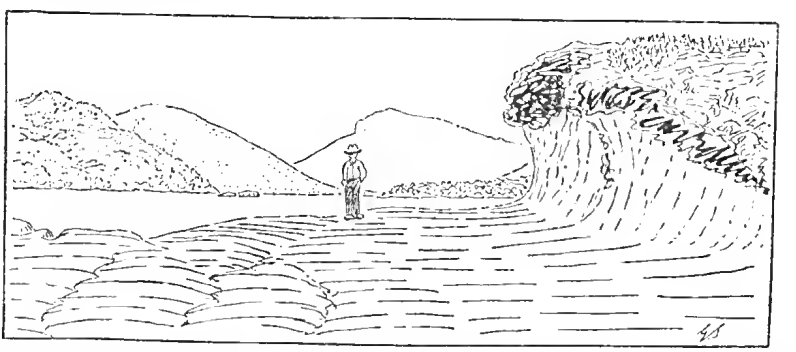
eastern side a marginal bench is apparent, elevated uniformly about 4 feet above high-tide level. (See Text-fig. 11.) This bench persists also into Hill Inlet, in the south-eastern portion of the island, along the shores of which low cliffs are cut in the volcanic agglomerates. The bench there usually attains a width of 18 to 20 feet (see Text-fig. 12), and is elevated about 4 feet above high-tide mark.

South of Hill Inlet, along Whitehaven Bay, the shore is low and fringed by long curved beaches of the whitest sand, behind which are terraced sand dunes. The hills are not much more than 400 feet high.

The western shoreline between the northern extremity of the island and Daniel Point, a distance of 5 miles, is linear and steep. It is dissected by small steep gullies and is not deeply embayed. To the south-east of Daniel Point is a large, branched embayment. Here is Cid Harbour, between Cid and Whitsunday Islands. Cliffing is confined to spur-end bluffs. The most westerly point of the island is Reef Point, to the south-east of which are two small embayments, filled with coral reefs.

Fringing reefs are irregularly developed. As in the case of Hook Island they are usually present in the bays, and are absent from rocky headlands which face deep water.

All the embayments are enormously silted. Hill Inlet (see Text-fig. 12) practically dries at low water. Gulnare Inlet (see Text-fig. 13), which is a beautiful example of a drowned valley with steep shores, is also considerably silted.



Text-fig. 12.—Bench 4 feet above H.W.M., and cliffs in Hill Inlet, Whitsunday Island. The view is looking up the inlet. Note the joints in the surface of the bench in the foreground. The rocks are coarse agglomerates.

In plan the shape of the island appears to be defined by lines running nearly N.-S. and E.-W., which are intersected by another series trending N.E.-S.W. and N.W.-S.E. The former series coincides approximately with the dip and strike of the rocks, which may well have exercised an important control in determining the lineaments. The latter seems to correspond to the direction of the trend lines, and the direction at right angles to them. It is suggested that such portions as, for example, Cid Harbour, Gulnare Inlet, and Hill Inlet, have been determined by fracturing, and that the peculiar shape of the island is, in part, to be explained as a fracture pattern.

*Cid Island.*—This island lies to the west of Whitsunday Island. It is 1½ mile long and 1 mile broad, and reaches a height of 683 feet. The hillsides are steep, and are pine- and jungle-clad.

The rock collected from this island proved to be a fine-grained and finely stratified tuff. This is overlain by a thick and massive flow of basalt. The rocks strike N. 20° W., and dip to the S.W. at 40°. In places the basalt is vesicular. Sometimes a rude columnar jointing is developed. At Hill Rock (80 feet high) just to the west of the island, a junction of tuff and basalt was examined.

The island is dissected on all sides by small steep gullies, and is comparatively slightly embayed. From a distance it appears rounded in profile, but close to the shoreline it is rugged and cliffy. Huge blocks of basalt fringe the water-line along the north side.

No fringing reefs of any extent are developed. They are present in Cid Harbour to the east and at Reef Point to the south. The submarine profile appears to be too steep to be favourable for their development.

There is no sign of recent elevation. All the cliffs (which may be 40–50 feet high) are within reach of the sea.

*Henning Island.*—This lies in the same alignment as Cid Island, Reef Point, and Dent Island. It is nearly a mile long and is very narrow in proportion. It is 227 feet high.

Its geology is unknown. In all probability the rocks are volcanic.

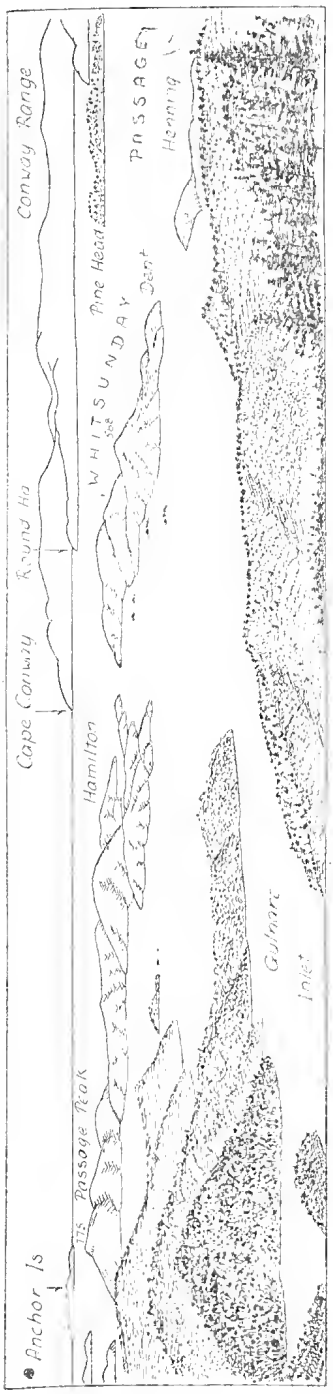
It resembles a small edition of Dent Island, and is cliffed on the western side, where it has deep water close-to.

*Dent Island* is about 3 miles long and three-quarters of a mile wide. In the northern portion is a hill 568 feet high, while near the lighthouse the main ridge is about 500 feet high.

The rocks are coarse agglomerates, which strike parallel to the long axis of the island (N. 10° W.) and dip steeply to the westward. As usual they simulate the weathering of granite, appearing often in rounded boulders and tors.

From the west the island appears steep, with an undulating crest-line rising to rounded hills. It is dissected by small consequent gullies and is embayed, but not deeply. (See Text-fig. 13.) In places the shoreline has been cut into rocky bluffs, which are nearly always controlled by joints. The extent of the marine erosion is comparatively insignificant compared to the extent of the cliffing on islands like Hook and Hayman *supra*. The boat-landing at the lighthouse is in a small chine excavated between two joints, and with a shingle beach of coral fragments and pebbles.

There is deep water all along the western side of the island. No fringing reefs are developed there. They are confined to the northern and eastern sides.




Text-fig. 13.—Sketch from the summit of Whitsunday Peak, looking south. The drowning of the islands is strikingly shown. Note the absence of cliffs. In the distance the high coastal ranges are shown in profile. Compare with Text-fig. 19.

*Hamilton Island* lies half a mile to the east of Dent Island, from which it is separated by Dent Passage. (See Text-fig. 13.) It is roughly triangular in shape. There are several peaks, Passage Peak at the eastern end being 775 feet high.

The geology is unknown. The rocks are probably volcanic.

The island is elaborately and maturely dissected, and is deeply embayed. Seen from the summit of Whitsunday Peak (Text-fig. 13) it presents a perfect example of a drowned island.

Fringing reefs are well developed in the embayments. No reefs are present on the south-east side, where the spurs, cliffed into small bluffs, plunge into deep water, 10 to 11 fathoms, close-to.

*Pentecost (or Lion) Island.*—This is one of the most picturesque islands of the Cumberland Group. It is like a "tower rising out of the sea," as it is described in the Admiralty publications. It is 941 feet high, and from the northward or the southward has the appearance of a lion couchant. (See Text-fig. 14.)

It is eroded on all sides into cliffs, which plunge into deep water of 10 to 20 fathoms.

Its position is incorrectly charted. (Admiralty Chart 347.)

*Lindeman Island.*—Through being joined to Cawarra Head, the length of this island in a N.-S. direction is a little over 2 miles, while its width E.-W. is about $1\frac{3}{4}$ mile. Its greatest height is in the S.E., where it rises to 712 feet.

Geologically the island is composed of clasties and lavas of the volcanic series. In a letter to the writer, Prof. H. C. Richards[13] describes the rocks observed there in 1923, as follows:—

[13] H. C. Richards: Private communication, 1925.

"The island appears to be composed of andesitic material—hornblende andesite. On the S.W. corner much andesitic agglomerate exists, and is interbedded with the andesitic lavas. The agglomerate is very coarse in places, with fragments reaching more than a foot in diameter, and grades down to quite fine material of a clastic nature. The strike of the clastic material is approximately N.N.W. and S.S.E., with a dip of 45° to the E.N.E."

These observations were confirmed by the writer's examination. So uniform is the volcanic series as a whole that the above description would apply to almost every place at which the writer has seen them. At Lindeman Island, however, they appeared to be basaltic rather than andesitic and, indeed, a rock sectioned proved to be a ferro-magnesian-free basalt.

The topography of the island is represented in a block-diagram. (See Text-fig. 14.) It is well dissected by small gullies and is embayed in a series of sandy coves separated by rocky headlands. Small bluffs and cliffs are developed, but they are comparatively insignificant. They are too small to show in the block-diagram.

At the northern end, Cawarra Head is an example of an island which has become tied to Lindeman Island by an extensive fringing reef. The eastern side of the Head is well cliffed, the cliffs being about 100 feet high.

Fringing reefs are developed chiefly in the bays.

There is no evidence anywhere of recent uplift.

*Sydney Island* lies almost a mile to the west of Lindeman Island. (See Text-fig. 14.) It is small, is tabular in appearance, and is well cliffed. It shows no traces of recent elevation.

A rock west of Cawarra Head is marked on the chart as 115 feet high. This is tabular and cliffed (see Text-fig. 14) and has a sandy, bouldery flat on its N.W. side joining it to another smaller cliffed rock.

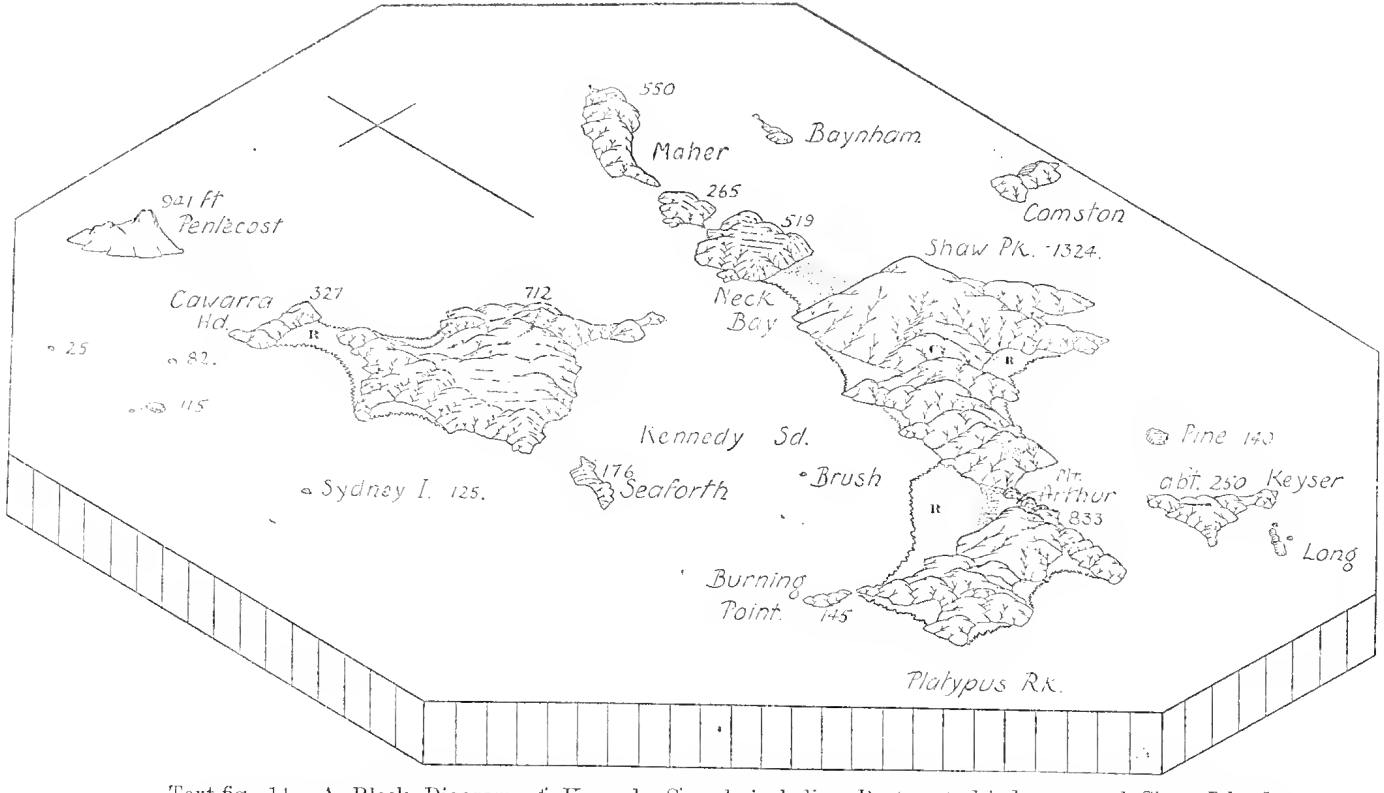
*Seaforth Island.*—This lies to the south of Lindeman Island, in Kennedy Sound. It is small, being a little over half a mile long and narrow for its length. It is 176 feet high.

It is composed of pink granite.

On all sides it is cliffed into small rocky bluffs.

*Shaw Island.*—This island is some 5½ miles long and about 2 miles wide at its broadest part. It is mountainous, Shaw Peak in the northern portion being 1,324 feet high, and forming a conspicuous landmark. Mount Arthur, in the southern portion of the island, is 833 feet high. Other peaks along the backbone of the island are 606 feet, 664 feet, and 708 feet; north of Neck Bay the highest peak is 519 feet high.

The island is of considerable geological interest. It is composed partly of granite and partly of volcanic rocks. South of Neck Bay the island is wholly granitic. This rock is very homogeneous, is pink in




Text-fig. 14.—A Block Diagram of Kennedy Sound, including Pentecost, Lindeman, and Shaw Islands. The scale of the figure does not allow the drawing of the small cliffs and bluffs around the islands. Fringing reefs are shown by zig-zag lines, and in some cases are labelled *R*. *C* is a low gap separating Shaw Peak block from the middle block.

colour, and the quartz is often slightly opalescent. It is prominently jointed, several sets of planes being developed. The strongest and most persistent set strikes N. 20° W., and dips steeply to the west. Another set strikes N. 60° E., and dips to the S. at about 50°. Numerous small basic dykes intrude the granite.

North of Neck Bay the island is composed of volcanic materials exactly similar to those described from the other islands to the north. Clastic materials predominate, and range from fine-grained tuffs to coarse agglomerates. The beds strike N. 80° W., and dip steeply to the northward at angles of 60°–75°. With these are intercalated andesitic and basaltic lavas. A chocolate colouration of the rocks is very characteristic.

The junction of the granite and the volcanic beds is concealed beneath the sandy isthmus of Neck Bay.

The salient features of the topography are delineated with sufficient accuracy in the block-diagram. (Text-fig. 14.) The island is broken by low gaps into five blocks, or masses (or six, if Maher Island is included). The gap at Neck Bay is low and sandy, and is practically at sea-level. The gap to the north of this is but 30 feet wide at high tide. To the north, again, a shallow channel intervenes between Maher and Shaw Islands. South of the Shaw Peak block two deep bays on opposite sides of the island are separated by a rocky saddle about 50 feet above sea-level ("C" in the block-diagram), while north of the Mount Arthur block the saddle is only 25 feet high. There is no doubt that gaps such as Neck Bay are drowned cols, and that they are being choked by the combined action of coral reefs and long-shore currents.

The island is deeply embayed, all the bays being considerably silted up. The bay heads are usually filled with mangrove thickets, behind which are sandy grassed flats. The island is really more indented than a study of its charted plan would lead one to suppose. (See Admiralty Chart 498.)

Numerous rocky spur-end bluffs are developed, but there is no sign of a bench of marine erosion. There is no trace of recent elevation. The small cliffs are all within reach of the present sea-level, and merely on the evidence of the sandy flats in the bay-heads it is considered that elevation cannot be postulated. Compare with the case of Haslewood Island.

Fringing reefs are well developed. In Kennedy Sound, eastward of Burning Point there is a large reef nearly half a mile wide. Most of the bays are choked with coral flats, which dry at low water. Growing corals are practically confined to the outer face of the reef.

In Kennedy Sound are some small rocky islands. *Brush Island* is low and rounded and is covered with a few sparse shrubs. It is formed of granite in which vertical joints are well developed, and which is intruded by a basic dyke. *Yellow Rock* is also formed of pink granite.

*Maher Island* continues the trend of Shaw Island to the northward. It is 550 feet high.

It is formed of volcanic materials, but the details of the geology are unknown.

The island is strongly cliffed on the eastern side, where the cliffs reach the unusual height of 300 feet. On the north and west sides the cliffing is not so well marked, but at the extreme south-west end of the island a sea cave has been cut right through a spur. The island is covered with grass and pines and patches of vine scrub.

*Baynham Island* is small and about 300 feet high.

Geologically it appears to be composed of volcanic materials.

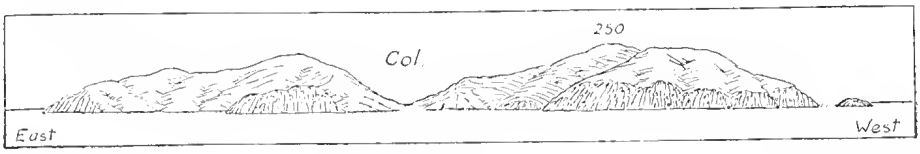
On the eastern side it is very considerably cliffed, in one place almost to its summit. These are plunging cliffs, with depths of 10–15 fathoms at their foot.

*Comston Island* is formed of granite. It is rounded in profile, and is not embayed. In comparison with Baynham it is only insignificantly cliffed.

*Triangle Island*, to the south, is long and low, and reaches a height of 150 feet. It is formed of granite, and has been cut into small bluffs and chines.

*Mansell Island* is triangular in shape, and is 630 feet high. It is sub-conical in shape.

It is formed of the same pink granite as Shaw and the other islands hereabouts.




Text-fig. 15.—Sketch of Keyser Island from Shaw Island. Plunging cliffs are well developed.

On all sides it has been eroded into small cliffs, which are rather more accentuated on the east. On this side the cliffs plunge straight into deep water of 15–20 fathoms.

*Pine Islet* is 140 feet high, and is formed of pink granite. On all sides it has been cut into cliffs and low bluffs.

*Keyser Island* is roughly triangular in shape. It is about 250 feet high, and is composed of pink granite.

The island is divided into two blocks by a low col. Seen from Shaw Peak (Text-fig. 15) it is rounded in profile, and is "nibbled" on all sides into small cliffs and chines. It is not deeply embayed, but there are several pretty sandy beaches. There is no sign of a wave-cut bench, and no trace of recent elevation.

*Thomas Island.*—This is a convenient spot at which to terminate the description of the northern islands of the Cumberland Group.

The island is 450 feet high. It is formed of pink granite. The dissection is well advanced, and in consequence the island is well embayed. Cliffing, even on the exposed eastern side, is confined to the spur-ends.

*Islands to the West of Whitsunday Passage.*

Compared to the islands of the Cumberland Group, described above, all these islands are small and rocky. They group themselves into festoons, which are indicated by trend lines in Text-fig. 25, A. These are sub-parallel to the trend of the coastal ranges.

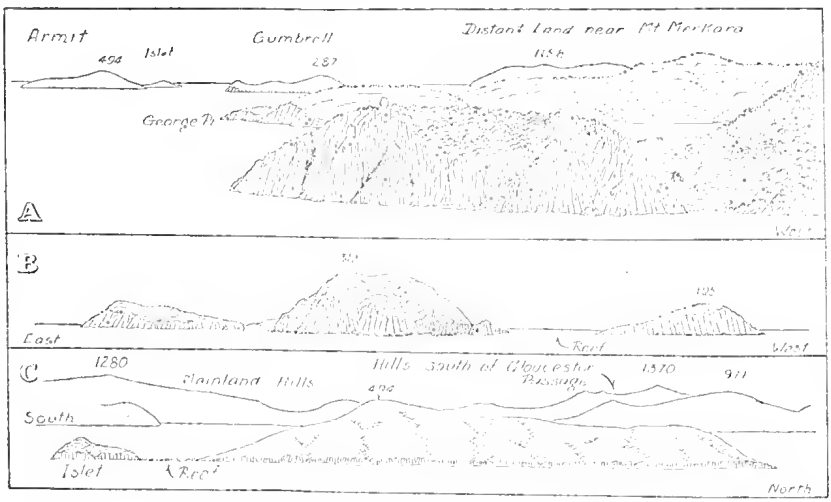
Throughout the descriptions, refer to Text-figs. 1 and 2.

*Rattray Island.*—This is the most northerly of the islands (see Text-fig. 1). It is 340 feet high, and about half a mile long, and is narrow for its length.

The island is composed of volcanic rocks, but the details are unknown.

The island is broken by a low col, near the northern end, into two portions. Along the northern, eastern, and south-eastern sides it is a good deal cliffed. The cliffs become less pronounced towards the south-west end, where there is a sandy flat, behind which the island is uncliffed. On all sides it is dissected by steep, parallel, consequent gullies.

*Eshelby Island.*—This island is low and rocky. It is formed of pink granite, and is cliffed into bluffs and chines. The beaches are formed of coral shingle, although no fringing reefs are developed.



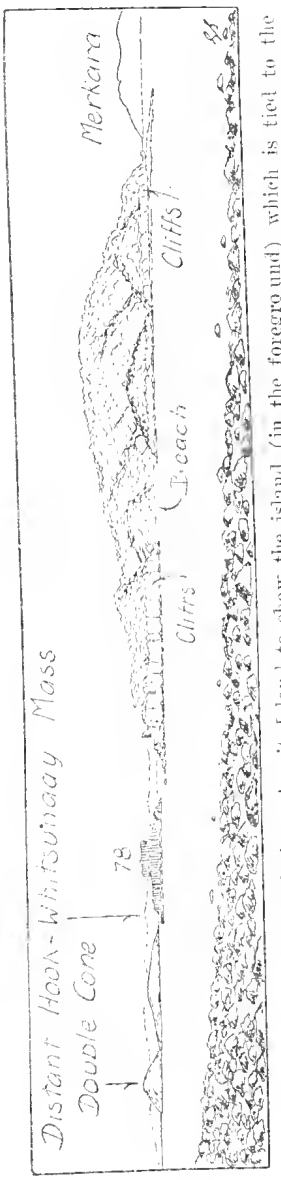

Text-fig. 16.—(A) Sketch of the eastern end of Saddleback Island, showing cliffs. Note the predominance of vertical joints in the granite. Looking south-east towards Armit Island. (B) The northern side of Double Cone Island. The well-developed cliffs are present only on the lee side of the island, the weather side being protected by a fringing reef, which also links the two islands. (C) Sketch of Armit Island and profile of the distant mainland, made from Double Cone Island. Note the radial character of the gullies and the extent of cliffing along the exposed eastern side. Note, too, the extensive fringing reef at the southern end.

*Saddleback Island* is small and rocky. It is double peaked, being divided into two portions by a well-marked col or saddle. (See Text-fig. 16, A.)

Geologically the island is composed of pink granite. This is strongly jointed, the joints striking approximately N.-S., and being either vertical or steeply inclined to the eastward. Basic dykes are common.

On all sides the island is dissected by small steep gullies. Particularly on the eastern side it is well cliffed. A fringing reef extends off the S.W. and S.E. sides, and at the S.W. end of the island is a sandy flat.

*Olden Island.*—This island is low, rounded, and grassy. It is 269 feet high.




Text-fig. 17.—Sketch from Armit Island to show the island (in the foreground and) which is tied to the main island by an extensive fringing reef. Note the cliffs. Note particularly the wall-like and even-topped Hook-Whitsunday mass.

It is formed of dark-coloured rocks, which are almost certainly volcanics.

On all sides of the island sea-cut bluffs are developed, which are now covered with vegetation and are above the reach of the waves. An elevation of small extent is indicated. A coral reef extends off the southern point.

*Gumbrell Island* is rectangular and double peaked. The higher peak is 287 feet high. (See Text-fig. 16, A.)

The rocks are granite, which closely re-embles the granite of Saddleback Island.

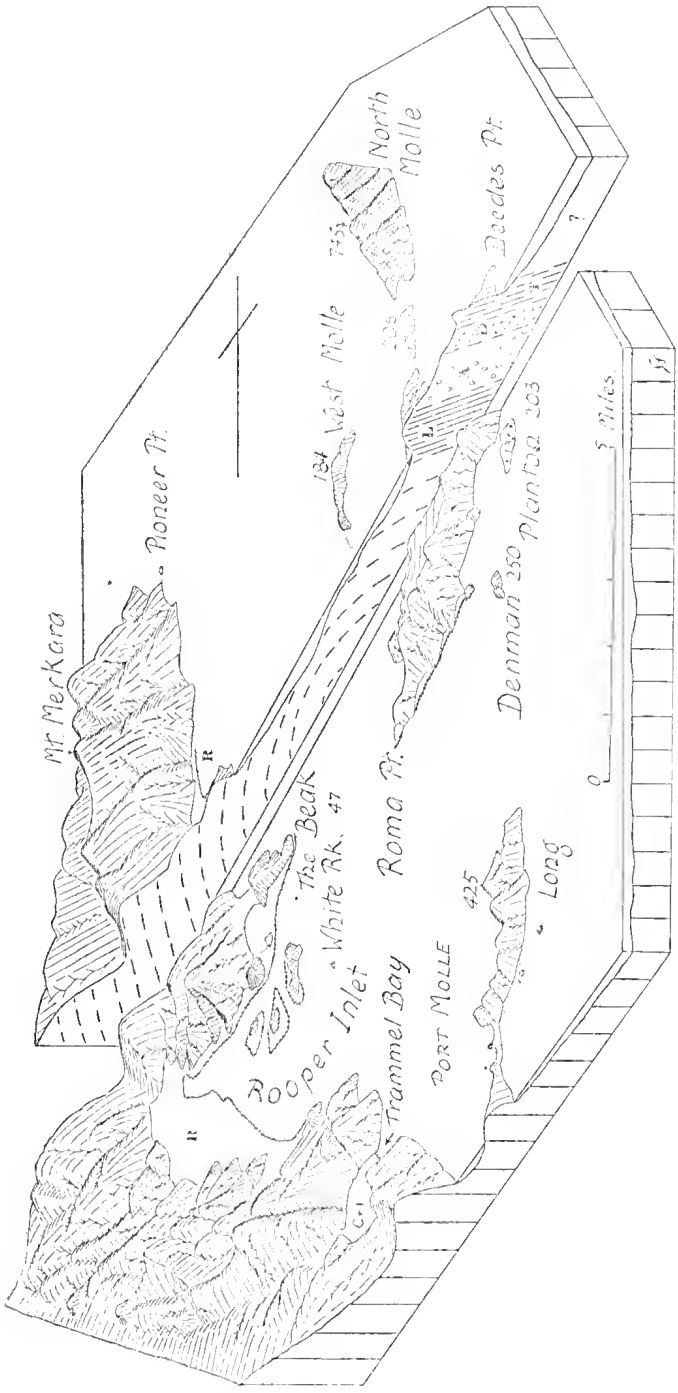
The island is a good deal cliffed, particularly along the eastern side. The cliffs are broken into chines by numerous vertical joints and dyke fissures. At the south-eastern corner is a flat sandy area a few feet above sea-level. A fringing reef extends off the southern end.

*Armit Islands.*—This group comprises one large island and two small ones, the latter being tied to the former by an extensive fringing reef. (See Text-fig. 17.)

The main island is nearly a mile long, in a N.-S. line, and about half a mile wide. It rises to one jungle-clad peak 494 feet high.

Geologically the island is formed of typical members of the volcanic series. These consist chiefly of coarse agglomerates, which are the lowest rocks exposed. Many of the rock fragments are over a foot in diameter. They are overlain by a thick series of basaltic flows. The petrological characters of these rocks are very interesting. The series strikes approximately N.-S., and dips very steeply to the west.

On the northern and eastern sides the island is steep and cliffy. (See Text-fig. 16, C.) The cliffs are usually determined by joint planes.




Text-fig. 18.—A Block Diagram of the Molle Islands and the adjacent mainland. The block has been drawn apart to show the probable geological structure. *L*, Lavas; *A*, Agglomerates; *D*, Dolerite; and *T*, Tuffs, "Cherts," &c. Fringing reefs are shown by zig-zag lines and are lettered *R*.

There are also little sea-caves and stacks, all determined by joints, which are now removed from the action of the sea at its present level. They indicate an elevation of about 5 feet above the present high-water level.

On all sides the island is dissected by small consequent gullies. Behind the beach on the western side is an extensive sandy flat well above the present sea-level. The lessees of the island informed me that a few feet beneath the surface are found slabs of recent beach-conglomerate, similar to the slabs one finds on the present beaches, and like those which have been commented upon by Jukes, Agassiz, and others.

The large fringing reef mentioned above connects the main island to the smaller ones. The larger of these is rounded in profile, but is cliffed on all sides. (See Text-fig. 17.) Sand- and boulder-beaches fringe the water's edge. The other islet is small and rocky, and has been cliffed back almost to extinction.

To the east of the islets above mentioned lies a rock, 78 feet high, which is considerably cliffed on all sides, and around which no reef is developed, since it stands in deep water of over 10 fathoms.

*Double Cone Island.*—Under this name are grouped two islands, which are jointed together by an extensive fringing reef. Both are small and rocky, though covered with dense vegetation. The larger island is 312 feet high, and the smaller 195 feet.

Geologically the islands are composed of rocks of the volcanic series, consisting of coarse agglomerates and basalts. These strike about N. 10° W., and dip steeply to the east. In places acid dykes traverse the rocks.

The islands are dissected by small consequent gullies. On the southern side, where the reef affords protection, they are practically uncliffed. On the northern aspect, although this is the sheltered side, the islands are strongly cliffed. (See Text-fig. 16, B.) There are no traces of recent elevation.

*Edwin Rock.*—This is only a few feet above sea-level. It appears to be formed of rocks of the volcanic series. In all probability this represents the remnants of a small rocky islet which has been cliffed to extinction. Nearby is an islet 43 feet high, which is formed of dark-coloured rocks and is cliffed on all sides.

*Grassy Island* is about three-quarters of a mile long and half a mile wide. It is 481 feet high.

The rocks appear to be volcanic.

In profile it is rounded, and is much lower at the southern end, where it extends into two points. Like Olden Island, marginal sea-cut bluffs are present which are now removed beyond the reach of the sea. This must indicate a recent elevation.

A fringing reef fills the bay on the southern side and extends nearly half a mile to the southward.

*Molle Islands.*—These constitute one of the most interesting groups studied. They comprise about half-a-dozen islands, the salient features of which are indicated in a block-diagram. (Text-fig. 18.)

The islands are composed of rocks of the volcanic series, which strike uniformly N. 20° W., and dip to the N.E. at 60°–70°. The lowest rocks exposed are basaltic lavas. These are overlain by a series of agglomerates, with "knots" up to 3 inches in diameter. These in turn are followed by a thick, coarse-grained dolerite flow (or sill?), the field relations of which are unfortunately obscure. Overlying the dolerite are hard, dark-black, fine-grained cherty rocks (resembling radiolarian cherts) intercalated with thinly bedded lavas and tuffs. The cherts are probably tuffaceous in origin, and show signs of having been secondarily hardened. No radiolaria have been detected in thin slices.

North Molle Island is about 2 miles long and half a mile wide. It is an elongated ridge, with an undulating crestline, the highest point of which is Mount Chaine, 745 feet high. It is covered with grass and patches of scrub. On either side it is dissected by steep gullies, but it is not deeply embayed. In places it has been cut into small bluffs. At its southern end is a grassed, sandy flat. There are no well-developed fringing reefs.

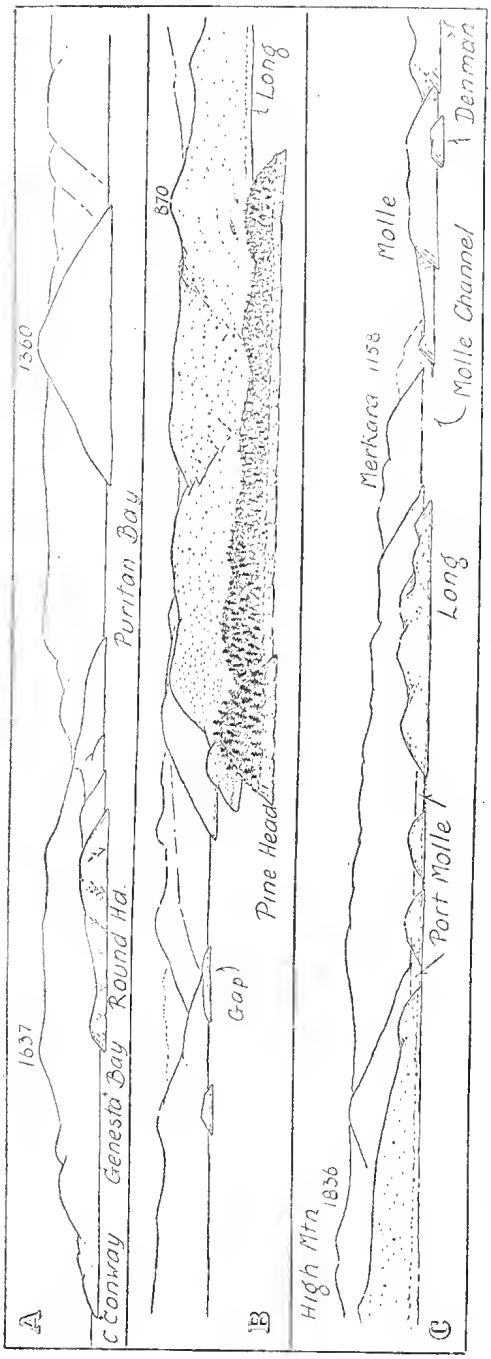
Mid-Molle Island, though more wooded, is a smaller edition of North Molle. It is cliffed into small bluffs. The bluffs appear to be above the reach of the sea, and in consequence a slight elevation may be deduced. The island is connected to Molle Island proper by a tombolo of rocky boulders and coral shingle.

Molle Island is the largest of the group. It is a little over 1½ mile long in a N.-S. direction, and is about 1 mile broad at its widest part. In shape it is tabular, rising into a roundish dome in Mount Jeffreys (622 feet high). On all sides the island is dissected by small gullies (see Text-fig. 18), and it is not deeply embayed. The steep spur-ends are cut into bluffs, and along the southern shores of the bay on the north side is a wave-cut notch, which is now removed above the action of the sea, indicating a recent elevation of about 4 feet above present high-tide mark. Fringing reefs are developed in the bays along the western and southern sides. In the northern bay the writer saw only a few stunted blocks of *Goniastraea*. This island is used for sheep by Mr. Carden Collins. His house, overlooking the northern bay, stands on a sandy flat well above the sea. The flat may be due to the recent elevation, but it could equally well be merely an old hurricane beach.

West Molle Island is long and narrow, and is 184 feet high. It is pine-clad, and is cut into the usual bluffs.

Denman and Planton Islands (250 and 203 feet high, respectively) are two small rocky islands lying close to Molle Island. Their geological nature is unknown, but the rocks are probably volcanic. They present no features of special interest.

*The Shute Islets* lie in Rooper Inlet (see Text-fig. 18). They are all small and rocky, and are of no particular interest, except for the fact that large fringing reefs are developed round them.




Text-fig. 19.—Panoramic view, from the summit of Dent Island, of the coastal ranges to the westward between Cape Conway and the Molle Islands. In *B*, note the cliffs around Pine and Long Islands. Note also the gap; this separates the masses lettered *K* and *E* in Text-figs. 1 and 2.

*White Rock* is 47 feet high, and is cliffed all round. It is tabular in shape, and shows no traces of recent elevation.

*Long Island.*—This island is about 5 miles long, and is narrow for its length. It varies in height from 870 feet in the southern portion to 468 feet in the northern.

The details of its geology are unknown. The rocks are volcanic, and are described by Jukes, who states that they dip to the W. or W.S.W.[14]

The island is really a long ridge trending parallel to the coastal ranges. Port Molle, between the island and the mainland, is a beautiful example of a drowned valley. All the shorelines are well embayed. The southern portion of the island is steep and is dissected by steep gullies. (See Text-fig. 19, B and C.) In the north the island is lower, and is broken by low cols into a number of rounded residuals, which are tied to each other by sandy necks. (See Text-fig. 18.) The eastern shoreline is cliffed along its entire length.

*Pine Island.*—This picturesque island, which is opposite Dent Island at the narrowest part of the Whitsunday Passage, is about 1½ mile long, and rises to 340 feet. (See Text-fig. 13.) Its geology is unknown.

[14] J. Beete Jukes: "Narrative of the Surveying Voyage of H.M.S. 'Fly,' during 1842-46." 2 Vols., London, 1847.

It is a good deal cliffed, particularly on Pine Head, a rounded, dome-shaped, rocky mass at the south end of the island. (See Text-fig. 19, C.) These cliffs plunge into deep water of 20 fathoms. No fringing reefs are developed.

At this point it is convenient to terminate the descriptions of the island festoons.

### The Coastal Ranges.

As shown in Text-figs. 1 and 3, these trend from Cape Conway in the south to Gloucester Head in the north, a distance of over 50 miles. Generally over 1,000 feet high, they reach their greatest elevation in Mount Dryander (2,690 feet). They are broken by four transverse gaps or cols into several units (masses, or blocks), which in the Text-figs. are indicated by the letters K, E, D, and G.

In such a large area, most of which is rugged and inaccessible, and covered with dense tropical jungle, geological field work is very difficult. In the following descriptions are inserted a number of scattered observations, which were made at various places during the course of the physiographic work. These are far from complete, but they serve to show that the coastal ranges are composed partly of granites, and partly of folded volcanics, which are undoubtedly members of the same suite as the volcanics of the island festoons, and which the writer believes to be of Permo-Carboniferous (Lower Bowen) age.

*Gloucester Island*, separated from the mainland by a shallow and narrow channel, forms the northerly termination of the coastal ranges. The island is 5 miles long and 2 miles broad, and is mountainous, rising to a height of 1,870 feet in Mount Bertha.[15] Geologically it is composed of granite.

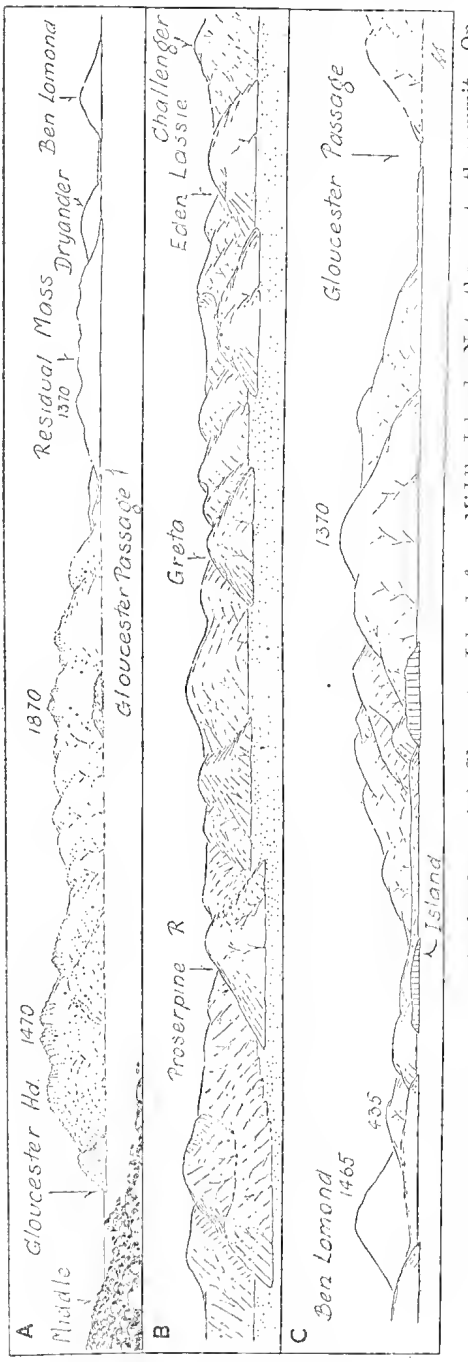
The island is dissected on either side by steep consequent gullies. In profile it has an undulating crestline, which in places forms arrete-like ridges. (See Text-fig. 20, A.) The embayments are comparatively moderate in extent. At the S.W. corner of the island the embayments are filled by elevated sandy flats similar to those which have been noticed at Haslewood and Shaw Islands. Along the exposed eastern side the cliffing is surprisingly moderate in amount. At the N.E. end of the island the magnificent spurs of Gloucester Head plunge into deep water of 17 fathoms. Fringing reefs are not developed to any extent, except in Gloucester Passage.

*Passage Islet* in Gloucester Passage is small and rocky. It is formed of granite, and is cliffed on all sides. A fringing reef extends to the south-east.

Continuing the trend of Gloucester Island to the south of Gloucester Passage is a residual, granitic mass, rising to 1,370 feet (see Text-fig. 20,

[15] Recently (1926) redetermined by the officers of H.M.A.S. "Moresby" to be 1,906 feet high.

A and C), and terminating at its northern end in Cape Gloucester. The dissection is deep and elaborate, but in plan the shoreline is not deeply embayed, owing to the bay-heads being filled with sandy flats well above sea-level. These flats are possibly due to recent elevation of 5 to 10 feet. Slabs of beach-conglomerate are common along the beaches.




Text-fig. 20.—Three panoramic sketches. (A) Gloucester Island, from Middle Island. Note the saw-tooth summit. On the right note the residual mass sketched below in C. On the left is a typical boulder beach of a granitic island. (B) The appearance of the eastern face of the highlands which border the western plateau. This is as seen from Gloucester Passage. The foreground has been eliminated and the viewpoint raised. Note the deep notches cut by the creeks and the Proserpine River, and the relative flatness of the corridor floor. (C) The Residual Mass, south of Gloucester Passage, from Saddleback Island.

The same trend-line (see Text-fig. 25, A) is continued to the south in Ben Lomond (1,465 feet high), an isolated conical-shaped, granite residual standing at the mouth of the Gregory River on the right bank. (See Text-fig. 20, A and C.) Ben Lomond is of considerable interest because of the occurrence there of limestones, which may, some day, be of commercial value. These have been reported upon by E. C. Saint Smith,[16] who considers that the pink and grey granite has intruded a sedimentary series of Carboniferous (?) age. The strike of the limestone is recorded as N.W.-S.E., and the dip as 70° to the N.E. The rock is stated to be largely oolitic, and only obscure fossil traces have been found.

[16] E. C. Saint Smith: "Limestones at Ben Lomond, Bowen District." Qld. Govt. Min. Jour., Vol. XIX., 1918, pp. 559-60.

During the course of a short visit to Ben Lomond the writer had an opportunity of examining the limestone, which is a homogeneous, grey-blue rock containing occasional crinoid stems. The outcrop examined is exposed in the bed of a small creek (dry) a few yards from the beach. Contrary to Saint Smith's observations, the bed strikes N. 30° E., and dips to the N.W. at a very steep angle. It is associated with typical rocks of the volcanic series, being overlain by tuffs, lavas, and agglomerates. To the south-eastward, towards the foot of Ben Lomond, the outcrops of the series are obscured by granitic detritus from the hillsides, and a junction between the granite and the volcanics was not observed. If the writer's suggestion be correct, that these volcanic rocks are of Permo-Carboniferous (Lower Bowen) age, then the Ben Lomond limestone is possibly to be correlated with the St. Helens Creek limestone, which has been described by J. H. Reid,[17] and which is associated with undoubted Lower Bowen clastic volcanics.

Between Ben Lomond and George Point is a wide lowland gap, which separates the residual mass of Cape Gloucester from the northern hills of the Dryander mass. On the Edgecumbe Bay side of this lowland the shores are low and fringed with dense thickets of mangroves, behind which are extensive bare clay salt-pans. On its seaward side the gap is fringed by an extensive coral flat. Some low residual hills rise out of the flat land of the gap. (See Text-fig. 20, C.)

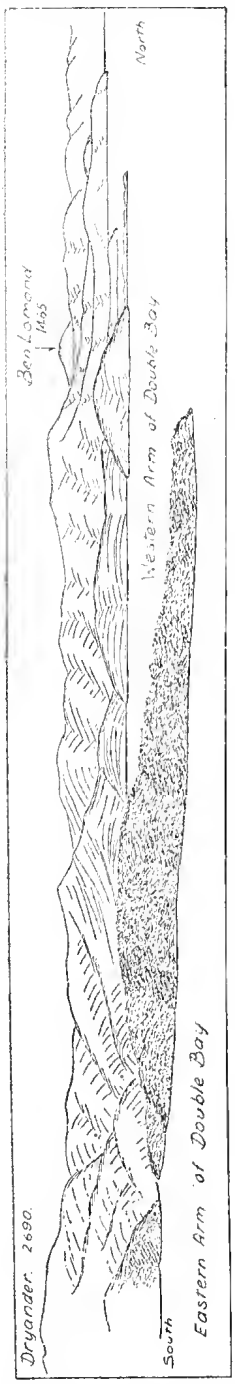
George Point is a granitic headland, and is well cliffed on the eastern side. (See Text-fig. 16, A.) To the south, between this point and Pioneer Bay, the coastline is broken by a succession of bays all opening to the northward. These lie between steep spurs which descend from the dissected highlands forming the northern extension of the Dryander mass (D in Text-figs. 1 and 3). The amount of dissection of this portion of the coastline is well shown in Text-fig. 21. The headland to the east of Double Bay, from the summit of which the above sketch was made, is massive and high. It is composed of volcanic rocks, chiefly basalts. These strike N. 10° W., and dip at 40° to the westward. Grimstone Point is long and low, and somewhat resembles the northern end of Long Island (described above) in that it consists of rounded hills connected by low cols which are nearly at sea-level.

Mount Dryander (2,690 feet high) is a rounded knob rising above the general level of a deeply dissected "plateau" surface. (See Text-figs. 1 and 3.) The geology of this portion of the coastal range is unknown, but on the northern and north-eastern aspect of Mount Dryander are many bare rock faces and cliffy escarpments, these features being typical elsewhere of rocks of the volcanic series.

To the south the dissected margin of the Dryander mass forms the northern boundary of Cannon Valley, which is a well-defined low gap extending from Pioneer Bay towards Proserpine. It completely pierces the coastal ranges, and separates the Dryander mass (D in the figures) from the Conway Range (E). The valley is occupied by Crofton and

[17] J. H. Reid: "Permo-Carboniferous Geology of Queensland—Additional Notes." Qld. Govt. Min. Jour., Vol. XXV., 1924, pp. 46-8.

Brandy Creeks and their tributaries. The former heads in a low divide only a couple of miles from Pioneer Bay, On its southern side the valley is bounded by the foothills of the deeply dissected Conway Range. This has a marked scarp-like appearance.




Text-fig. 21.—Sketch of Double Bay and the coastal ranges from the 681-foot summit of the high peninsula west of Grimstone Point. Note the elaborate dissection, the embayments, and the absence of cliffs.

The southern boundary of Cannon Valley is continued to the eastward along the deeply embayed shores of Pioneer Bay to Pioneer Point. In the second bay to the westward of Pioneer Point the rocks exposed are fine-grained lavas, and coarse- to fine-grained tuffs. The series has a general E.–W. strike, and dips to the S. at 25°. (See Text-fig. 2.) Almora Rock, near Pioneer Point, consists of massive porphyritic lavas, which also strike E.–W., and dip to the S. at a moderate angle.

South of Pioneer Bay the coastal ranges are high, steep, and deeply dissected. Their general appearance from the eastward is shown in Text-fig. 19. Along this section of the coastline there is a tendency for deep valleys to be formed parallel to the coastline. This has resulted in the development of such features as Mount Merkara (1,158 feet high), which has been nearly separated from the mainland by drowning. As shown in Text-fig. 18, Rooper Inlet and Funnel Bay are connected through a low gap of sub-aerial erosion, characterised by interlocking spurs. Further drowning would result in the formation of a channel such as Port Molle, which has almost certainly been produced in this manner. These features have been commented upon by Richards and Hedley[18] as follows:—

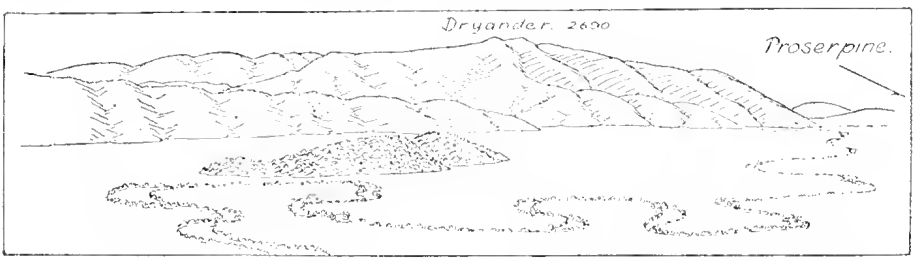
> "From Cape Capricorn to Gloucester Head (Lat. 19° 59′ S.) marked evidence of subsidence exists in the form of peaks of drowned mountain ranges—especially about the Whitsunday Passage. Secondly, one sees in this part of the coast steep and high promontories which narrowly avert separation from the mainland by low-lying regions parallel to their length; and thirdly, this area faces the greatest width of continental shelf along Eastern Australia."

[18] H. C. Richards and Chas. Hedley: Report submitted to the Great Barrier Reef Committee, 13th July, 1923. Queensland Geographical Journal, Vol. XXXVIII.

The Conway Range is terminated in the south by a gap opposite the southern end of Long Island. This gap is low but narrow, and leads right through the ranges to Repulse Bay. It is shown in Text-figs. 13 and 19, B.

To the south of the gap the ranges are flat-topped and wall-like. They terminate in the south at Cape Conway. Round Head is another example of a promontory which has nearly been separated from the mainland by drowning. It has low plunging cliffs along its eastern margin, facing deep water (12 to 15 fathoms). Cape Conway is but little cliffed. Its spurs plunge into deep water of 10 to 15 fathoms. Along this section of the coast fringing reefs are not developed.

The western slopes of the coastal ranges overlook a broad lowland region which stretches from Repulse Bay to Edgecumbe Bay. This lowland or "corridor" is described in the next section. From the west the ranges appear scarp-like. They are deeply dissected by short steep gorges. The transition between the flat land of the corridor and the steep slopes of the highlands is very abrupt. This is well shown by a sketch from the summit of Ben Lomond (Text-fig. 22).




Text-fig. 22.—Sketch from the summit of Ben Lomond, showing the western aspect of the coastal ranges. The meanders of the Gregory River, fringed with thickets of mangroves over the flat corridor floor, are very striking. Note the rounded residual.

*Holbourne Island and Nares Rock.*—The trend of the Conway–Gloucester coastal ranges is possibly continued in these isolated remnants.

Holbourne Island is interesting chiefly owing to the evidence recently brought forward by Marshall, Richards, and Walkom,[19] relative to a recent emergence there of a moderate amount. Their remarks are prefaced by a general description of the island and the literature pertaining to it. Traces of elevation are claimed in the shape of raised beaches, caves in the cliffs now removed above the present sea-level, and an "elevated" fringing reef which is now dead. With regard to the last, however, it has been pointed out by Rainford[20] that the Holbourne Island reef was destroyed during the 1918 cyclone, and that until then it was in a flourishing condition. This conclusion may be accepted.

[19] P. Marshall, H. C. Richards, and A. B. Walkom: "Recent Emergence at Holbourne Island, Great Barrier Reef." Trans. Roy. Geog. Soc. A'sia. (Qld.). Vol. 1, 1925, p, 29.

[20] E. H. Rainford: Extract from a letter to the Secretary, Great Barrier Reef Committee. Same volume, p. 161.

Along the east and north-eastern sides the island is well cliffed. The granite cliffs plunge directly into deep water of 23 and 24 fathoms. The fringing reef is confined to the southern side.

Nares Rock, to the south, is composed of fissile quartzite. It has been eroded considerably by the sea along joint planes, which correspond approximately to the cardinal directions.[21]

*The Repulse Islands.*—These islands, to the south-westward of Cape Conway, appear to continue the trend of the coastal ranges from the east of Proserpine. Their geology is unknown. They are all low, rounded, and grassy, and on the east and south-east are fairly well cliffed.

### The Bowen-Proserpine Lowland or "Corridor."

This lowland stretches between Repulse and Edgecumbe Bays, and is undoubtedly one of the most interesting features of the whole area. It was first remarked by Cook, who, after telling of the naming of Edgecumbe Bay, observes:—

> "The land in the bottom of this bay I could but just see from the masthead; it is very low and is a continuation of the same lowland as is at the bottom of Repulse Bay."[22]

To the east the corridor is bounded by the deeply-dissected western side of the coastal ranges, which have been described above. To the west is a vast, rugged mass of highlands, which forms the border of the main "plateau" of Eastern Queensland. The corridor is thus trough-like in character.[23] (See Text-fig. 3.) To the south it is continued partly as the coastal plain, and partly as the relatively shallow Hillsborough Channel. The North Coast Railway has taken advantage of this natural feature, and between Proserpine and Bowen traverses it almost without a deviation.

The streams draining from either side into the corridor debouch through V-gorges on to the plain, and flow either to Edgecumbe Bay or to Repulse Bay. In consequence a valley divide is formed. This is close to Redhill (see Text-fig. 1), and being less than 100 feet high it is quite imperceptible. When viewed from an aeroplane[24] the corridor floor appears quite flat from end to end. The isohyets trend obliquely across

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[21] E. C. Saint Smith: Rock Phosphate Deposit on Holbourne Island, near Bowen." Qld. Govt. Min. Jour., Vol. XX., 1919, p. 124.

[22] "Captain Cook's Journal—A Literal Translation of the original MSS." Edited by Capt. W. J. L. Wharton, R.N., F.R.S. London, 1893.

[23] The term "corridor" is used here in the same sense as applied by F. Jardine: "The Drainage of the Atherton Tableland." Trans. Roy. Geog. Soc. A'sia. (Qld.), Vol, 1, 1925, p. 133.

[24] Early in November, 1926, the writer had the privilege of flying from Bowen over Gloucester Island and portion of the Great Barrier Reef to the north-east of Hook Island, in a flying-boat belonging to 101 Flight, of the Royal Australian Air Force.

the corridor. Bowen, at the northern end, in a rain-shadow area, is comparatively dry, receiving only 40 inches per annum; Proserpine, at the southern end, is much wetter, receiving 75 inches. This difference affects the nature of the watercourses, and also the vegetation. The streams at the northern end are torrential in character, and during the rainy season are subject to floods. For months at a time their beds are merely sandy channels, 20 to 30 feet deep, and perhaps containing a few waterholes. They wind across undulating, park-like pastoral country, which is timbered by casuarinas, tea-trees, iron barks, and boxes. Further south the creeks are perennial in character, and are defined by belts of vine-scrub. All hilly eminences are scrub-clad, and in addition are vegetated by coastal elm, pencil cedar (now nearly all cut out), Mackay cedar, milkwood, stinging trees, and lantana. On the coastal flats are gums, bloodwoods, and tea-trees.

The geology of the corridor is not well known. Owing to its very gentle relief it is covered largely by alluvial material, which is probably partly fluviatile and partly marine in origin. At the northern end granitic rocks predominate (see Text-fig. 2). Around Proserpine rocks of the volcanic series were examined by the writer (June, 1925), and subsequently (1926) C. C. Morton informed the writer that he had noted similar rocks to the westward of the town, along the road to the Normanby goldfield. It is not known how far to the northward these volcanic rocks extend.

*The Islands in Edgecumbe Bay.*—The shores of Edgecumbe Bay are low and fringed with enormous thickets of mangroves. Near the mouth of the Gregory River, which is tidal for about 10 miles (see Text-fig. 22), the mud and mangrove flats extend over a mile from the shore. The other creeks entering the bay are also tidal in their lower courses. The islands in the bay represent small residuals (generally granitic) which have been isolated by drowning.

*Middle Island.*—This island, formed of pink granite, is by far the most interesting. It is 180 feet high, and is nearly a mile long.

The island was visited by Agassiz[25] in 1896. To its description he devoted considerable detail, and in addition published several excellent photographs. An opponent of the Darwin–Dana hypothesis, he believed that at Middle Island he had obtained evidence in support of his views. He writes:—

> ". . . . came upon a fine exposure of a coarse conglomerate (Plate IV.), similar to that described by Jukes. This conglomerate beach rock is elevated fully 8 feet above the highest high-water mark. . . . The faces of the elevated conglomerate exposed to the action of the sea were pitted and honeycombed much as the æolian rocks of the Bahamas where exposed to the force of the sea. . . ."

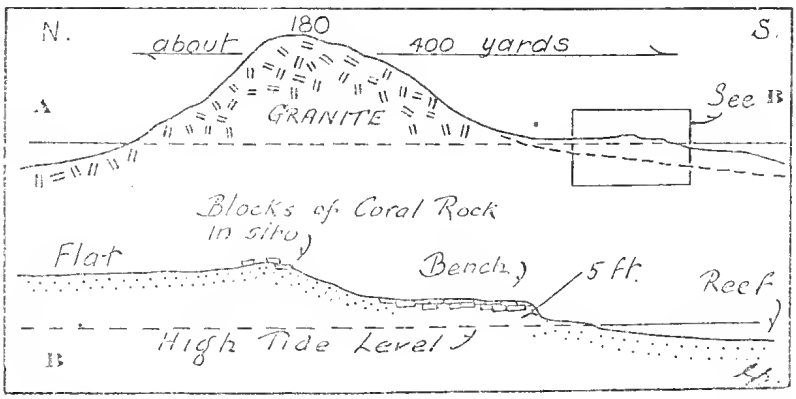
[25] Alexander Agassiz: Ibid.

It is clear that Agassiz regarded this mass as an elevated reef, for further on in the report he writes:—

> ". . . . in stretches still closer to the mainland (as at Middle Island and elsewhere) we still find large patches of the elevated reef which have not been completely eroded or changed into negro-heads."

This view, of course, is quite erroneous.[26]

During July, 1925, the writer examined the conglomerate described in the quotations above. The rock is merely the ordinary beach conglomerate, slabs of which are commonly seen along the beaches of so




Text-fig. 23.—Sketch sections at Middle Island. (A) North-south section, to show the extent of the elevated flat. (B) Detailed section of the edge of the flat and the raised bench there, which is cut in recent beach conglomerate.

many of the islands of the Queensland coast. The slabs are not horizontal, but are inclined (as usual) at about 8°. Often the dip is to seaward, but this is not an invariable rule. Without entering here into the question of the origin of this type of rock, the section measured is as follows (see Text-fig. 23):—

The fringing reef covers at high tide. Five feet above the high-tide level is a bench 12 to 15 feet wide. This is cut in the soft conglomerate and does not show on the granite shores of the island. It cuts horizontally across the basset edges of the dipping beach rock. Behind the bench is a bank, 6 to 8 feet high, consisting of slabs of blackened beach rock apparently *in situ*. Behind this again is an extensive, flat sandy area from which the island slopes up. Such a section is comparable to that recorded by Andrews[27] at the South Palm Island, Fantome Island, and elsewhere.

There is undoubted evidence here of recent elevation. As a whole the island is steep-to. It is well cliffed along the north and east sides, the cliffs plunging into deep water of 5 to 9 fathoms. Being massive and irregularly jointed, the granite does not favour rapid benching.

*Stone Island.*—The island is crescentic in plan, and is made up of

[26] Alexander Agassiz: Ibid., pp. 107-9, p. 121.

[27] E. C. Andrews: Ibid., p. 157, &c.

three or four small rounded hills, of which the highest is only 90 feet high. It is composed of felsites and porphyries, which in places are intruded by dykes of the underlying granite.

On all sides the island is cliffed into small bluffs. These are now removed above the attack of the sea, and are subdued in profile as well as being covered with vegetation. This indicates a slight elevation. This inference is confirmed by a bench cut in beach rock exposed along the north-west side of the island, in a manner similar to the bench (described above) at Middle Island.

Extensive fringing reefs are developed to the south, and also in Shoalwater Bay, which is completely filled. These reefs were killed during the 1918 cyclone, but they are now rapidly recuperating. The story of their destruction has been separately related by Hedley[28] and Rainford.[29] In June, 1925, the growing corals consisted chiefly of small colonies of *Goniastræa, Merulina, Turbinaria, Fungia,* &c. Soft corals were flourishing.

*Thomas and Poole Islands.*—These are of small extent, low, and rounded. They are tied to the shores of the mainland by spits of coral shingle and pebbles. The latter island is formed of basaltic rocks.[30] This is probably related to the volcanic rocks which outcrop near the base of Ben Lomond. (See page 32.)

*Bowen.*—The town is situated on the shores of Port Denison. It is built on the slopes of two or three low, rounded, granite residuals about 100 feet in height. To the north and east of the town there are other residuals, Flagstaff Hill (200 feet high) and Edgecumbe Heights (250 feet high). Behind these are extensive salt-pan flats and mangrove swamps.

The extent of recent marine material around Bowen is very considerable. The Botanic Gardens and Muller's Lagoon are areas where the marine nature of the deposits is undoubted. Near the latter place there are small patches of *devil-devil* "country," which the writer accepts as direct evidence for the former presence there of mangrove swamp conditions. To the south-east of the town, towards Mount Pring, there are large bare clay salt-pans, which cover at spring tides. The salt-pan "country" merges almost imperceptibly into the flat grass-lands towards Don and Merinda. In this respect there is a resemblance to the well-known Townsville plain.

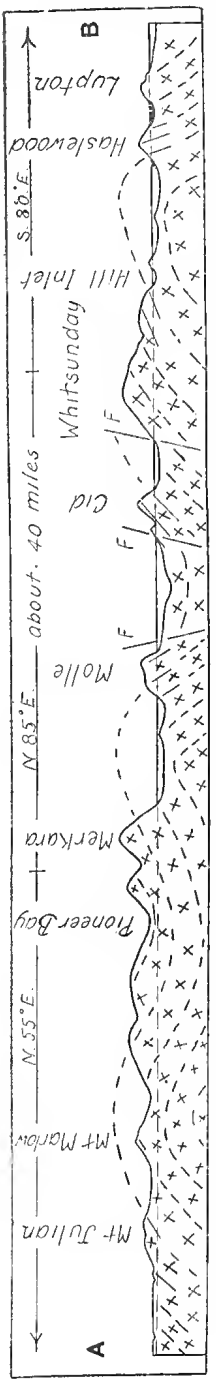
Evidence of recent elevation may be seen at Bowen in the shape of a low, wave-cut bluff which commences near the Customs House, is found all round Calton Hill (a low residual determined by a patch of felsitic

[28] Chas. Hedley: "Natural Destruction of a Coral Reef." Trans. Roy. Geog. Soc. A'sia. (Q'ld.)), Vol. 1, 1925, p. 35.

[29] E. H. Rainford: "Destruction of the Whitsunday Group Fringing Reefs." Aust. Museum Mag., Vol. 2, No. 5, pp. 175-7.

[30] According to Lieut. C. G. Little, R.A.N., of H.M.A.S. "Moresby."

and dacitic material included in the granite), and so round near the Rifle Range towards Muller's Lagoon. This is now above the attack of the waves, and is usually covered with vegetation and subdued in profile. It resembles the bluffs cut around Stone Island.




Text-fig. 24.—Topographic and Geological Section along the line *A-B*. Text-fig. 1. The geological structure is conjectural only, and is based on small sections observed at Mt. Julian, Mt. Marlow, Pioneer Bay, Molle, Clid, and Whitsunday Islands, Hill Inlet, and Haslewood Island. The faults are inferred from the topography.

It would seem that residuals such as Flagstaff Hill, Edgecumbe Heights, and Mount Nutt were formerly islands in a shallow sea, and that they have become tied on to the land by a slight uplift. At the same time it is interesting in this connection to recall some notes published by Jensen,[31] which were furnished him by H. L. Kesteven, on the question of land-formation by the sea in Moreton Bay. Mangroves are considered to act as a natural rake, as follows:—

> ". . . The numbers of closely placed trees stop all that floats on the surface, while the roots stop heavier rubbish (loosened weeds) and sand moving along the bottom. Once our embryonic island reaches high-water level the rank grasses of the district take hold and do their share in raising its height."

Presumably a stage in this process would be reached when the mangroves would die owing to submergence by the tides becoming gradually less and less frequent. In the swamps at Bowen one continually comes across areas of stunted and apparently dying mangroves, and in addition, although one sees numerous fragmentary claws of the crabs belonging to the genus *Uca*, not a single living specimen was ever seen. Does this mean that the process outlined above is acting at Bowen at present? If so, could islands become tied to the mainland in this manner during the course of a long stillstand? The writer believes that both questions are to be answered in the affirmative.

*Proserpine.*—This is a small town based on the sugar industry in the wetter, southern portion of the corridor. The country around is very flat. Small residual hills rise out of the plain. Many of these are covered with dense jungle, although some have been cleared (in the days of Kanaka labour) for sugar.

[31] H. I. Jensen: "The Geology of the Glasshouse Mountains and District." Proc. Linn. Soc. N.S.W., 1903, pp. 873-74.

To the south-east of the town large areas of alluvium obscure the outcrops of the country rocks. But these appear along creek beds and in the residuals mentioned above. On the road from Proserpine to Cannonvale the Proserpine River is crossed near its junction with Brandy Creek. At that point fine-grained, yellowish tuffs are exposed, striking N. 10° W., and dipping at 40°–50° to the westward. Further to the east, at Mount Julian, there is a series of basaltic and andesitic lavas, together with tuffs and coarse agglomerates. These are exactly similar to the types described from the festoon islands. Some of the rock fragments are as much as 4 inches in diameter. These rocks strike N. 10° W., and dip to the west at 30°. It is probable that an anticlinal limb exists between Mount Julian and the junction of Brandy Creek and the Proserpine River. (See Text-figs. 2 and 24.) Further to the eastward again, towards Mount Marlow, tuffs and basalts were examined in the road cuttings.

A good deal of time and skill would be required to disentangle the complex relationships of the rocks in this interesting area.

To the south of Proserpine and along the western shores of Repulse Bay the corridor is continued as the coastal plain. Creeks like Lethe Brook, Kelsey, and Goorganga, and the O'Connell River, meander over the flat lands and reach the sea through tidal channels. Normally these flats are swampy, and often during the summer wet season they are transformed into shallow lakes. At Goorganga linear ridges are said to exist, and my informant considered these to be old strand lines. Unfortunately opportunity was not afforded of examining these in detail.

### The Highlands along the Margin of the Western "Plateau."

On its western side the Bowen-Proserpine corridor is bounded by a deeply dissected mass of highlands, representing the edge of the main "plateau" of Eastern Australia, homologous to and probably homotaxial with the Mount Morgan plateau to the south, recently described by Jardine[32] in a paper dealing with the Lower Fitzroy.

The Lands Department maps of the area (Counties of Herbert and Salisbury) show the usual "centipede" mountain chains which are so misleading. Chief of these is the Clarke Range (refer to Text-figs. 1 and 3), which is in part the boundary between the streams flowing into the Burdekin system and those following short, direct courses to the Pacific, and in part the divide between the Bowen and the Bogie Rivers, both tributaries of the Burdekin.

In reality we are dealing here with a plateau region in which the dissection along the margin is well advanced. Linear mountain ranges are occasionally found, and these are residuals of the plateau.

For the most part the highlands are composed of granitic rocks. Occasional patches of basic plutonic rocks are associated with the

[32] F. Jardine: "The Physiography of the Lower Fitzroy Basin." Queensland Geographical Journal, Vol. XXXVIII., 1923.

granites, as at Mount Pring, to the west of Bowen, where a hornblende gabbro occurs, at the position marked M in Text-fig. 2. It is not known whether the granites and the gabbros are co-magmatic. The "plateau" is occupied by the Permo-Carboniferous basin, and by small areas of recent volcanic rocks.

The chief coastal streams are the Don River and Euri Creek, flowing north into the sea near Bowen, and the Proserpine and Andromache–O'Connell Rivers flowing in a general easterly direction to Repulse Bay.

Although on the map the Don and Euri Creek appear as well-developed streams, they are really in the nature of torrents. Often they are sand-beds, or merely a chain of water-holes, and during the summer rains they are liable to destructive floods. In their lower courses they have deposited alluvium, and they tend to branch into distributaries, such as Sandy Creek and the Alligator Creek Lagoons near Merinda. To the west of Bowen the sugar and tomato farms are based on this alluvium. Shallow wells sunk in the silts provide sources of water for irrigation.

The Don River is about 48 miles long. It and its tributaries have profoundly notched the plateau edge (see Text-fig. 3). Heading in the Clarke Range near the Normanby goldfield, its head-waters for some 20 miles have a general N.W.-S.E.E. trend, and it is quite likely that they represent a captured portion of the Burdekin system. The road from Bowen to the Normanby goldfield follows the Don to its head and then crosses the Clarke Range. R. L. Jack[33] described this journey long ago, and his concise remarks are of considerable physiographic interest. They are as follows:—

> "The road presents no difficulties for the first 45 miles, beyond being occasionally forced into the bed of the Don by the narrowing of the valley. At this point, however, some 6 miles from Normanby the road and river issue from a narrow gorge. Above the gorge the track struggles for 3 miles over steep ridges and across deep gullies, through the middle of an amphitheatre hemmed in by the cliffs of the Clarke Range, whose southern lip it at last scales by a long sidling. . . . From the summit of the sidling to the Broken River the Clarke Range forms a gently-sloping tableland deeply channelled by the Grant, Green Creek, and the Dart, and their numerous tributaries, which break up the tableland into minor ranges."

In this description the contrast between the juvenile topography of the basin of the coastal stream and the maturity of the tableland surface is very well marked. It is clearly seen that the Clarke Range is nothing more than a line marking the limits of the ravages of the coastal streams upon the uplands. It is also clear that although the tableland is mature it is by no means a peneplain.

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[33] R. L. Jack: "Report on the Normanby and Marengō Goldfields." 1879. By authority. No. 5, Geol. Surv. Q'ld. Reports.

Euri Creek is about 31 miles long. It has deeply recessed the plateau. This valley has been followed by the Bowen-Collinsville railway, which passes through a gap in the ranges near Mount Pleasant Head Station (at A in Text-figs. 1 and 3), and so reaches the Bogie Valley. The gap is but 600 feet high, and at this point capture of the Upper Bogie by the coastal stream is imminent. In its lower course Euri Creek skirts a residual mass (R in the figures), of which the highest peaks are Mounts Mackenzie, Greentop, and Roundback. This is dissected by the gorges of Greentop and Sheep Station Creeks, both tributaries of Euri Creek.

East of the Don River valley and separating it from the corridor described above is a highland mass (C and H in the diagrams) which in its northern portion may be termed the Challenger mass—this mountain being the highest and most conspicuous elevation. On its eastern side it is dissected by the streams draining into the corridor. Viewed from the north and north-east it presents a rugged appearance, but it is comparatively even-topped. This aspect is sketched in Text-fig. 20, B. To the southward it is continued through Mounts Hector and Macguire (H) and so to the Clarke Range. It is the southern continuation of this mass which is shown in the Admiralty Chart as a "Level mountainous range from 3,000 to 4,000 feet." The Andromache River occupies a deep notch in the highlands. Morton,[34] referring to the track from Proserpine to the Normanby Goldfield, notes:—

> "A fine example of river terracing is seen on the right bank of the Andromache River close to the old Amelia Vale Homestead . . . showing that in very recent times uplifts have taken place."

West of the head of the Don River the Clarke Range is shown on the maps as trending a little north of west, forming with the Herbert Range the divide between the Bowen and Bogie Rivers. Actually the physiographic divide trends more to the north-west round the head of the Bogie River towards Mounts Aberdeen (2,980 feet) and Abbot (3,460 feet), and so to Cape Upstart (2,400 feet) (A, B, and U in the diagrams). From the north-east the level plain around Bowen and the deltas of the Don and Euri Creek extends to the foot of the residuals, which rise abruptly to 2,000 feet or so. The dissection has reached the stage of breaking the highlands into rounded residuals, of which Mount Roundback (2,400 feet), 12 miles due west of Bowen, is typical. North of the Mount Aberdeen mass is a low gap in the highlands which leads through to Eton Vale and Strathbogie *via* the Elliot River. (See Text-fig. 3.)

Cape Upstart (2,400 feet) continues the trend of the residuals to the north-westward. This granite mass was so named by Cook from the abruptness with which it rises from the lowlands at its base. It is

[34] C. C. Morton: "The Normanby Goldfield: Report on the Southern Portion." Q'ld. Govt. Min. Jour., Vol. XXI., 1920, p. 269.

tabular in shape and is deeply dissected. It is of interest because of having been visited long ago by Jukes and Stokes, who have each noted evidence of recent elevation nearby.

*The Collinsville "Plateau."*—This lies to the west of the Clarke Range and is drained by the Bowen River, a tributary of the Burdekin.

A description of the area has been recently given by Reid,[35] from whose report the following brief extracts are made:—

> "The Bowen River Coalfield . . . occupies almost the whole of the watershed of the Bowen River above its confluence with Pelican Creek. . . .
>
> "The coalfield occupies a low-lying basin varying from 600 to 1,000 feet above sea-level, fringed by ranges. On the north and east the Clarke Range rises to altitudes of 2,000 feet to 3,000 feet above sea-level. . . . On the north-west the Bowen River makes its escape by a wide gap through the enclosing ranges.
>
> "The greater portion of the coalfield occupies the rather mature valleys of the Upper Bowen. Viewed from a number of surrounding hills, most of it looks to be almost a dead-level plain. This flatness particularly applies to the area north of the Bowen River near Havilah. The southern portion is much more undulating to hilly. . . .
>
> "The Lower Bowen formation, largely composed of basic volcanics, gives rise to the rich blacksoil plains of Strathmore, Birallee, and elsewhere."

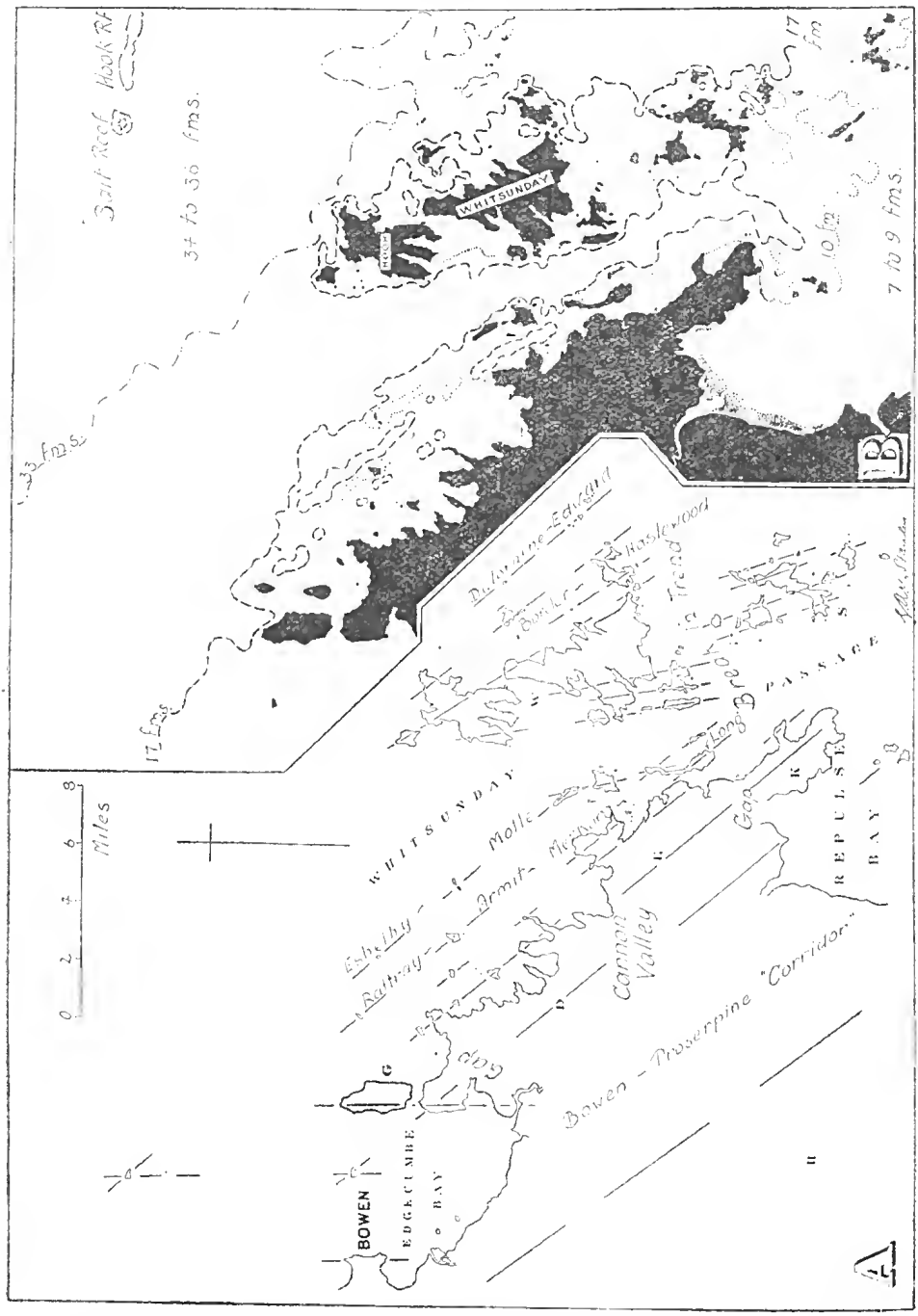
## THE BUILD OF THE AREA.

A stage has now been reached when some speculations may be indulged in as to the origin of the physiographic features which have been described in detail.

It has been seen that these can be grouped into units which are arranged along definite trend lines sub-parallel to the general trend of the coastline. In Text-fig. 25, A, the trend lines have been drawn. A study of this map shows that instead of being strictly parallel the trend lines converge, suggesting by their disposition the well-known diagrams of the outcrops on a level surface of plunging synclines and anticlines. It is interesting to recall in this connection that it is through the Whitsunday Islands that W. H. Bryan[36] has drawn an important anticlinal axis of the closing Mesozoic folding. The scattered geological observations made by the writer appear to confirm this (see Text-fig. 2), but

[35] J. H. Reid: "The Geology of the Bowen River Coalfield." Part 1. Qld. Govt. Min. Jour., Vol. XXV., 1924, p. 400.

[36] W. H. Bryan: "Earth Movements in Queensland," Pres. Add. Roy. Soc. Q'ld. Vol. XXXVII., 1925.




Text-fig. 25.—(A) Map of the Cumberland Islands and the mainland. The trend lines are indicated. Note how they converge. (B) Bathymetry of the area shown in (A). The 17-fathom line has been drawn (as it is closest to 100 feet) and also the 33-fathom line. In places the 10-fathom line has been added (dotted). The figure is lettered to correspond to Text-figs. 1 and 2.

the steep limb of the Whitsunday anticline faces east (see Text-fig. 24), which is unusual.

Again, the trend lines, instead of being continuous, are interrupted by breaks and gaps.

Along many of the trend lines recent elevation of small amount is well marked while it appears to be absent along others. Thus, for example, an elevated bench is formed all along the eastern side of the main festoon, while there is no sign of elevation along the western side. The festoon appears to be rising in the east and to be either sinking or stationary in the west.

Reference to Text-fig. 25, B, indicates the salient features of the bathymetry. East of the 33-fathom line (200 feet) is a gently undulating, shelf-like surface on which stand the units of the Great Barrier Reef. This line lies just east of the easternmost of the island festoons (the Deloraine-Edward arc), the members of which are sharp, rocky pinnacles rising abruptly to the surface. The 17-fathom isobath (100 feet) encloses the main festoon, and at the same time defines the long, narrow Whitsunday Passage, which in places reaches a depth of 50 fathoms. On the western side of the Passage the line limits a broad shelf on which stand several small fragmented festoons.

There is a striking alternation of island arcs and submarine "deeps." Behind (to the west of) the Deloraine-Edward arc is a 34-fathom trough. Behind the Border-Haslewood arc are several small deeps of over 17 fathoms. West of the main festoon is the deep Whitsunday Passage trench. Behind the Eshelby-Molle arc are two very long, narrow troughs. Behind the Rattray-Armit-Merkara-Long arc are several small deeps, as well as a low col (described above, p. 33) between Funnel Bay and Rooper Inlet.

The trend of Double Cone Island is continued far to the south-east as a submarine bank. Taken alone, this bank might perhaps be ascribed to the aggrading action of tidal streams, but it is very significant that the trend of Armit Island is continued as a 10-fathom bank just as far to the north-west, and furthermore this latter trend is also continued to the south-eastward in two small isolated 10-fathom patches.

The high coastal ranges are bordered on the west by a lowland area —the corridor—thus paralleling on a large scale the relationships of the deeps to the island festoons.

This systematic arrangement of the physiographic units suggests the operation of a broad control. The writer suggests that fracturing best explains the observed facts, and that morphologically the area consists of a series of fault blocks.

This suggestion is by no means new. Many years ago Professor David[37] wrote:—

> "From Gladstone to Cape York there is a remarkable coast, chiefly of the rück-land type, with mountain ranges from 2,000

[37] T. W. E. David: "Geology of the Commonwealth." Federal Handbook on Australia. 1914, pp. 249-50.

feet up to over 5,000 feet high (Bellenden Ker 5,428 feet) coming mostly close to the coastline, and having high islands like Hinchinbrook, which rises to an altitude of 3,560 feet, close inshore. This part of the coast and coastal shelf is so heavily faulted and studded with small islands which have survived the block-faulting, as to deserve Suess' title of *panzer horst.*"

The same authority[38] has been recently taken to task by Marks[39] for suggesting, among other things, that—

> "The Cumberland and Whitsunday Islands are almost certainly horsts among a network of faults."

Detailed geological evidence in support of this statement was not advanced, but it certainly represented a shrewd, and no doubt well-considered opinion. The writer regards it as being strongly supported by his recent physiographic studies.

In this connection the peculiarities in the plan of Whitsunday Island have already been commented upon. (Page 17.)

Observe that there is here no question of differential erosion. The physiographic units are constituted of many different types of rocks, and they cut across the geological boundaries. In the island festoons both granites and Palæozoic volcanics figure equally, and the same is true of the coastal ranges. Important as rock structure and relative resistance to weathering may be in determining topographic forms it does not seem feasible to consider that it has acted as the broad control, which is required by the systematic arrangement of the units.

In many respects the Cairns district presents parallel features to those of the area under consideration. The Malbon–Thompson Ranges correspond to the Gloucester–Conway coastal ranges, while the trough-like valley of the Russell and Mulgrave Rivers is the equivalent of the Bowen–Proserpine corridor. In the case of the latter no river comparable to the Mulgrave occupies it, but this is due to the difference in the aggregate rainfall of the two localities. Danes,[40] who has investigated the valley of the lower Mulgrave interpreted the corridor as a graben sunk beneath a broadly flexed or warped surface. Evidence was advanced in the shape of mangrove roots (*"racines de Palctuviers fossiles"*) in the clayey alluvial which covers the valley floor to show that marine conditions formerly existed in the corridor. It was considered, moreover, that Cape Grafton and Grant Hill, to the east of Trinity Inlet, were formerly islands in a shallow sea. And it was also suggested that by the combined action of tidal streams and coastal rivers (*"torrents"*).

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[38] T. W. E. David: "Notes on some of the Chief Tectonic Lines of Australia." Proc. Roy. Soc. N.S.W., 1911, p. 4.

[39] E. O. Marks: "Some Doubts in Queensland Physiography." Proc. Roy. Soc. Q'ld., Vol. XXXVI., 1924, p. 6.

[40] J. V. Danes: "La Region des Rivieres Barron et Russell (Queensland)." Ann. de Geographie, Vol. XXI., Paris, 1912.

assisted by recent elevation, the infilling of the corridor was brought about, while at the same time the islands were tied to the mainland.

This very important contribution to the theories of Queensland physiography seems to have escaped Marks' critical review. From a more recent study of the same area Jardine[41] is led to agree with Danes as to the rift nature of the corridor and the Cape Grafton peninsular, and he considers that the coastal ranges—

> "Were separated from the mainland by a narrow passage, resembling somewhat the features of the present-day Hinchinbrook Channel."

The writer has made several visits to the Cairns district during 1925-26, and opportunities were taken of reviewing the work of Danes and Jardine on the spot. There seems to be no reason to differ from them as to the rift origin of the Mulgrave valley and the subsequent processes by which it was infilled. It is suggested that the Bowen–Proserpine corridor had a similar tectonic origin and history.

The physiographic history of the area under consideration is interpreted as follows:—During the Pliocene the continent extended far to the east, certainly as far as the present position of the Great Barrier Reef and perhaps farther. Dissection had reached maturity, the streams occupying broad valleys and basins on the land surface, *but peneplanation was not nearly complete.* At the close (?) of the Pliocene, warping began along an axis parallel to the present coast, producing a gently bowed or flexed land surface. The movement was accompanied by much faulting and the formation of huge fault blocks. Cross faulting limited the longitudinal extension of the blocks, breaking them off, for example, at Gloucester and Hayman Islands. The blocks were not strictly parallel, and the graben of the Whitsunday Passage was wedge-shaped. During the Pleistocene, erosion set in and all the scarps and horsts were rapidly and deeply dissected. The deep dissection of islands such as Hook and Whitsunday, as well as the mature profiles of many others such as Hayman, Keyser, &c., is in striking contract to their pronounced embayments and the *relatively* small extent of cliffing along the headlands. This suggests that they were subjected to a long period of sub-aerial erosion before being submerged, and so subjected to the attack of the sea. A similar cycle is indicated for the highlands along the western border of the corridor, for, as indicated in Text-fig. 20, B, the level plain thrusts short arms into the valleys of the Proserpine River and Eden Lassie Creek, showing that these were well developed before submergence took place. The submergence, initiating the present coastline, occurred before the Glacial period, during which sea-level undoubtedly stood a good deal lower. Following Davis, the plunging cliffs, which we have seen are developed around many of the islands are interpreted as being produced through abrasion by the chilled and lowered ocean. During

[41] F. Jardine: "The Drainage of the Atherton Tableland." Trans. Roy. Geog. Soc. A'sia. (Q'ld.), Vol. 1, 1925, pp. 131-148.

post-Glacial times the sea-level rose gradually, drowning the horsts, producing island festoons, and flooding the graben. In Recent times the sea has eroded the islands only into small bluffs, and the infilling of the Bowen-Proserpine corridor has been accomplished in a similar manner to the present all-but-complete infilling of the Hinchinbrook Channel. Renewal of activity along the old fracture lines is indicated by the recent movements of elevation, which have already been discussed.

On this interpretation the materials of the corridor floor, as well as the enormous silt deposits which choke the *rias* of Hook and Whitsunday Islands, are regarded as being post-Glacial. Any pre-Glacial equivalents must have been hidden by the submergence, or else must have been removed by low-level erosion during the Glacial period.

## PHYSIOGRAPHY IN RELATION TO THE GREAT BARRIER REEF.

If the above interpretation of the physiographic history of the area be correct, then that portion of the Great Barrier Reef to the eastward is built on a broad area of the former continent which has been drowned by down-flexing and faulting. The even surface, revealed by the soundings, upon which the Reef units stand is due to the fact that any relics of subaerial relief have long since been obliterated by marine aggradation. This shelf-like area has probably never been above the sea since its submergence, even during the Glacial period, when sea-level may have stood some 30 fathoms lower than at the present day. It represents a maturely dissected Pliocene land surface which has been submerged, and which has been modified and smoothed by marine forces, chiefly extensive post-Glacial aggradation.[42]

Although the conditions demanded by Daly's Glacial-control theory are adopted, and the influence of low-level abrasion in producing plunging cliffs is recognised, nevertheless no positive support can be given to the view that the Great Barrier Reef is built on a rock shelf eroded around the margin of the continent by the lowered ocean of the Glacial period.

The Reef is thus regarded as Pleistocene, and probably pre-Glacial in age. During the Glacial Period its growth was inhibited in the north while it was probably destroyed in its southern portion. Its present development is almost entirely post-Glacial.

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[42] This interpretation must not be taken to apply to the Great Barrier Reef along its entire length of 1,200 miles. It can only refer to the Reef in the latitude of the small area investigated. Later investigations will probably show that Davis' concept of the marginal belts of the coral seas, and the climatic classification of islands, applies to the Queensland coast, and that the Reef can be separated into several provinces which have each had a different, though contemporaneous, physiographic evolution.

The origin of the Great Barrier Reef has been discussed by the most eminent physiographer of modern times—W. M. Davis. Recognising that geological and physiographic studies of islands and coastlines behind the reefs is of paramount importance in dealing with coral-reef problems, because of the information which they yield with regard to the origin of the reef foundations, Davis[43] has followed Andrews[44] in the latter's interpretation of the coastal highlands of Eastern Australia, more particularly with reference to New England, New South Wales. Considering the highlands as formed by successive broad uplifts or flexures separated by periods of partial peneplanation, the present reef is regarded as having been formed after a fourth flexure of the littoral belt, when a fairly wide coastal lowland was supposed to be reduced to the present narrow lowland. The former lowland was regarded as being fronted by a mature reef-plain, formed during the previous partial peneplanation of the coastal slopes, and it was on this submerged plain that the Barrier Reef grew. This cycle was supposed to be continued back through the series of flexures.

This scheme of evolution is radically different to that proposed by the writer. There is no evidence in the area, so far as could be seen, for several successive flexings of the coastal strip ever having taken place. It seems, indeed, rather bold to assume that because four peneplains have been recognised in New England (N.S.W.) that four have been formed in the near past along the Queensland littoral. Again, although post-Glacial aggradation has resulted in extensive silting and the reclamation of coastal corridors, nevertheless nothing like the amount of erosion has occurred in the area necessary to produce mature reef-plains, not once but several times, as demanded by Davis' scheme.

## CONCLUSION.

It is intended during 1926 to continue the physiographic investigation of the festoon islands and the coastline to the southward of the present area. It is impossible to tell what this study will reveal, and so it is perhaps rash to outline a scheme of physiographic evolution as above.

Briefly stated, one believes that the pre-Glacial reefs grew on the flexed- and faulted-down margin of the Pliocene continent. Coral growth was inhibited during the lowered and chilled sea-level of the Glacial period, but has been revived in post-Glacial times.

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[43] W. M. Davis: "The Great Barrier Reef of Australia." American Journal of Science, Nov., 1917.

[44] E. C. Andrews: "An Outline of the Tertiary History of New England." Rec. Geol. Surv. N.S.W., 1903.

## REFERENCES.

*Historical.*

CAPTAIN JAMES COOK: "Captain Cook's Journal—A Literal Transcription of the Original MSS." Edited by Capt. W. J. L. Wharton, R.N., F.R.S. London. 1893.

STAFF-SURGEON R. W. COPPINGER: "Cruise of the 'Alert'." 1883.

G. E. DALRYMPLE: Reports to the Government of Queensland.

MATTHEW FLINDERS: "A Voyage to Terra Australis in the years 1801, 02, 03, in H.M.S. 'Investigator,' and later in the 'Porpoise' and 'Cumberland' schooner." London. 2 Vols. Quarto. 1814.

J. BEETE JUKES: "Narrative of the Surveying Voyage of H.M.S. 'Fly,' during the years 1842-1846." London. 2 Vols. 1847.

CAPT. PHILLIP P. KING: "Narrative of a Survey of the Intertropical and Western Coasts of Australia, performed between the years 1818-1822." London. 2 Vols. 1827.

JOHN MACGILLIVRAY: "Narrative of the Voyage of H.M.S. 'Rattlesnake,' during 1846-1850." London. 2 Vols. 1852.

J. LORT STOKES, Commander R.N.: "Discoveries in Australia during the Voyage of H.M.S. 'Beagle,' in the years 1837-43." London. 2 Vols. 1846.

*Physiographic and Geological.*

AGASSIZ, ALEXANDER: " A Visit to the Great Barrier Reef of Australia in the steamer 'Croydon,' during April and May, 1896." Bull. Mus. Comp. Zool., Havard. Vol. XXVIII. No. 4. 1898.

ANDREWS, E. C.: "A Preliminary Note on the Geology of the Queensland Coast with reference to the Geography of the Queensland and New South Wales Plateaux." Proc. Linn Soc. N.S.W. Vol. XXVII. 1902.

ANDREWS, E. C.: "An Outline of the Tertiary History of New England." Rec. Geol. Surv. N.S.W. Vol. XII. Pt. 3. 1903, p. 140.

BRYAN, W. H.: "Earth Movements in Queensland." Pres. Add., Roy. Soc. Q'ld. Vol. XXXVII. 1925.

DALY, R. A.: Numerous papers dealing with the Glacial-control Theory.

DANES, J. V.: "La Region des Rivieres Barron et Russell, Queensland." Ann. de Geographie. Vol. XXI. 1912.

DAVID, T. W. E.: "Notes on some of the chief Tectonic Lines of Australia." Pres. Add., Proc. Roy. Soc. N.S.W. Vol. XLV. 1911.

DAVID, T. W. E.: "Geology of the Commonwealth." Federal Handbook on Australia. 1914.

DAVIS, W. M.: "The Great Barrier Reef of Australia." Am. Jour. Sci. 4th Series. Vol. XLIV. 1917.

HEDLEY, CHAS.: "Natural Destruction of a Coral Reef." Rep. Gt. Barrier Reef Com., Vol. I, 1925. (Trans. Roy. Geog. Soc. A'sia, Q'ld.).

JARDINE, F.: "The Physiography of the Lower Fitzroy Basin." Q'ld. Geog. Jour. Vol. XXXVIII. 1923.

JARDINE, F.: "The Physiography of the Port Curtis District." Rep. Gt. Barrier Reef Com., Vol. I, 1925. (Trans. Roy. Geog. Soc. A'sia, Q'ld.).

JARDINE, F.: "The Drainage of the Atherton Tableland." Rep. Gt. Barrier Reef Com., Vol. I, 1925. (Trans. Roy. Geog. Soc. A'sia, Q'ld.)

JACK, R. L.: "Report on the Normanby and Marengo Goldfields." Geol. Surv. Q'ld. Rept. No. 5. 1897.

JENSEN, H. I.: "The Geology of the Glasshouse Mountains and District." Proc. Linn. Soc. N.S.W. Vol. XXVIII. 1903.

MARKS, E. O.: "Some Doubts in Queensland Physiography." Pres. Add., Proc. Roy. Soc. Q'ld. Vol. XXXVI. 1924.

MARSHALL, P., RICHARDS, H. G., and WALKOM, A. B.: "Recent Emergence at Holbourne Island, Great Barrier Reef." Rep. Gt. Barrier Reef Com., Vol. I., 1925. (Trans. Roy. Geog. Soc. A'sia, Q'ld.).

MORTON, C. C.: "The Normanby Goldfield—Report on the Southern Portion." Pt. 2. Q'ld. Govt. Min. Jour. Vol. XXI. 1920.

QUEENSLAND GOVERNMENT INTELLIGENCE AND TOURIST BUREAU: "The Bowen District and the Whitsunday Passage." (Booklet.) 1924.

RAINFORD, E. H.: "Destruction of the Whitsunday Group Fringing Reefs." Aust. Mus. Mag. Vol. 2. No. 5. 1925.

RAINFORD, E. H.: "Extract from a letter to the Secretary, Great Barrier Reef Committee. Rep. Gt. Barrier Reef Com., Vol. I., 1925. (Trans. Roy. Geog. Soc. A'sia., Q'ld.)

REID, J. H.: "Geology of the Bowen River Coalfield." Q'ld. Govt. Min. Jour. Vol. XXV. 1924.

REID, J. H.: "Permo Carboniferous Geology of Queensland—Additional Notes." Q'ld. Govt. Min. Jour. Vol. XXV. 1924.

RICHARDS, H. C., and HEDLEY, CHAS.: Report submitted to the Great Barrier Reef Committee, 13th July, 1923. Q'ld. Geog. Jour. Vol. XXXVIII.

SAINT SMITH, E. C.: "Limestones at Ben Lomond, Bowen District." Q'ld. Govt. Min. Jour. Vol. XIX. 1918.

SAINT SMITH, E. C.: "Rock Phosphate Deposit on Holbourne Island, near Bowen." Q'ld. Govt. Min. Jour. Vol. XX. 1919.

VAUGHAN, T. W.: "Fossil Corals from Central America, Cuba, and Porto Rico, with an Account of the American Tertiary, Pleistocene, and Recent Coral Reefs." Bull. 103. U.S. Nat'l. Mus. 1919.

# REPORTS OF GREAT BARRIER REEF COMMITTEE

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## Some Remarks on Coral Formations

By

J. A. EDGELL, Captain, R.N.

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No. 2.

## SOME REMARKS ON CORAL FORMATIONS.

By J. A. Edgell, Captain, R.N.

(Text-figure 1.)

It is fairly obvious that, taken in the mass, the coral formations on a continental shelf present a different problem to the isolated atolls which are so numerous in certain parts of the oceans and which rise to the surface from the most profound depths with such abruptness.

Take as an example an atoll in the Indian Ocean—one of the Maldive Islands. In shape it is elliptical, the east and west axis being, say, 25 miles long and about half as long again as the north and south axis. On the outer perimeter coral grows luxuriantly everywhere, with perhaps in one or two places a small shallow ledge extending to seaward. Elsewhere the water is deep right up to the reef, and the 100-fathom line is almost coincident with the outer edge of the reef.

Let us suppose there are two or more principal openings leading inside, one of which carries depths of over 10 fathoms, and that there are a few narrow strips of sand sparsely vegetated, always above high water and distributed at fairly regular intervals along the crest of the reef.

Scattered amongst the islets and reefs, and contained within the outer and inner edges of the latter, there are sure to be pools or lagoons which never completely dry and with depths ranging from a few feet to 7 or 8 fathoms.

The true lagoon is, of course, the large area of water enclosed by the reef as a whole; it may have an area of 40 square miles or more and the depth may quite possibly be uniform and about 20 fathoms, whilst the interior is comparatively clear of dangers to surface navigation; on the other hand it frequently happens that the true lagoon is deep but has innumerable patches of foul ground composed of coral heads and extensive banks of coral.

A study of Admiralty Chart No. 66 will amply repay the time spent over it, and affords examples of the varieties of reefs mentioned.

I would like in particular to call attention to Wataru Reef and Ari Atoll. The former is roughly square and has only one entrance, this being apparently navigable by vessels of moderate draught. The entrance is situated near the south-west extremity of the reef; inside the lagoon the bottom is composed of mud, sand, and clay, and depths vary from 14 to over 20 fathoms over a quite large area. A few small islets with cocoanut palms on them are situated near the entrance.

If one accepts the theory that the formation and shape of a coral reef depend to a great extent on the direction of the prevailing winds

and currents, then it is difficult to account for the main opening in this reef being in the position which it occupies, having regard to the fact that the south-west monsoon blows steadily over the Maldives from May to December, and is by far the stronger of the two monsoons which prevail in this locality.

On the whole, openings in these large atolls are fairly evenly distributed on all sides and the curvature of individual reefs seems to conform more to the shape of the atoll as a whole than to be controlled by any fixed meteorological or oceanographical agent, being roughly crescent-shaped and inclined to the inner side of the atoll.

Turning to Ari Atoll, the position is found to be very different to Wataru Reef. Here the lagoon is of much greater extent and is thickly strewn with reefs of various sizes and small islands, with deep water in between them. If one accepts the theory already referred to, Dugati Island and its fringing coral bank would appear to be under the influence of a westerly source of supply; Matiwari is just the reverse. It may even be that the rule, if any, which applies to the Great Barrier Reef is inapplicable to the Maldives, and that, owing to their situation and the free access of oceanic waters to all portions of the reefs, there is very little evidence of starvation of any particular portion of the coral.

It has, I believe, been the custom in the past to examine *individual* coral atolls of the Great Barrier Reef, and possibly their relation to the whole reef area has not received as much consideration as would seem to be desirable.

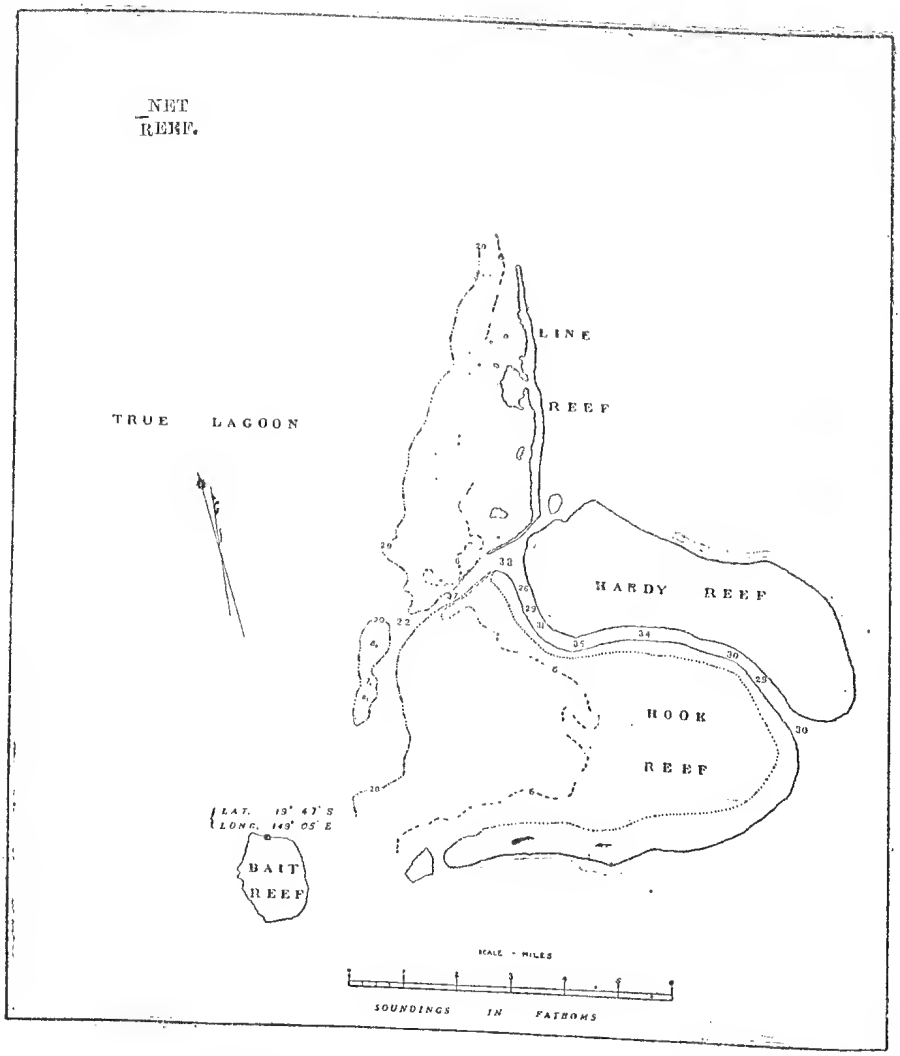
During recent surveying operations in the neighbourhood of Hook Reef, north-east of Whitsunday Islands, it was found possible to obtain an accurate delineation of several hitherto uncharted reefs, and incidentally the area covered proved to be of exceptional interest.

In appearance the newly-charted reefs are as shown in the attached sketch (Text-fig. 1). A comparison with Admiralty Chart No. 348, published June, 1888 (large corrections Nov. 1888) will show at once what new information has been obtained, and it is not too much to say that the character and contour of the reefs were quite unexpected and are most remarkable.

It is unfortunate that circumstances did not permit the charting of the reefs to the north-westward, but their existence is known, and that is all that is really necessary for the moment.

Taken separately, Bait, Hook, Hardy, Line, and Net reefs present the usual aspect that one is accustomed to inside the crest, viz., a shallow lagoon interspersed with nigger heads. On the west side of Hook and Line reefs a ledge of coral extends for a considerable distance with depths of 5-17 fathoms, and there are indications that a similar though smaller ledge extends off the east side of Net Reef. Hardy Reef is steep-to on all sides, and a most remarkable canal, some 500 yards wide and with depths of 30 fathoms, separates it from Hook Reef.

There is little, if any, evidence of impoverishment of the coral on any side of these reefs; it is luxuriant and healthy everywhere and appears to be just as thickly grouped on the lee or north-west side as on the weather side.




The canal is extremely interesting, the deep water is carried right through from end to end and bifurcates at the north-west end of Hardy Reef, one portion going to the north-east and the other to the westward, where it would appear to retain its relatively great depth until, having traversed the off-lying coral ledges (depths 5-17 fathoms), it joins the deeper water in what is perhaps the true lagoon of this particular group. This canal appears to be clear of dangers; the fringing coral overhangs on both sides and is visible as far as the eye can penetrate. The bottom is of sand and dead coral, and the tidal streams attain a rate of at least

5 knots, so that a good scour-out is in operation and fresh supplies of sea water are constantly available for the nourishment of the corals.

I have now reached in a somewhat tortuous way a position where it is permissible to make a suggestion regarding the study of the problem of coral formations in the future.

The suggestion which I have to make is that, instead of treating each reef as a separate entity, the student should examine a given area with a view to determining how many adjacent reefs can be fittingly selected with the object of indicating a deep-water lagoon of which the several reefs selected form the atoll.

The Hook Reef area, for instance, would seem to indicate the existence of a true lagoon within the area which is bounded by Bait, Hook, Line, Net, and other reefs to the north-westward, and it may be that a closer examination will show that the individual coral reefs of the Great Barrier Reef conform to the principle which is so well illustrated by Ari Atoll.

The late Mr. Charles Hedley, in "Transactions of the Royal Geographical Society of Australasia (Queensland)," Volume 1, says, in his report as Scientific Director for 1924, pages 158 and 159:—

> "The section of the reef that I saw from the 'Geranium' between the parallels of 17° and 18° south latitude is peculiarly destitute of sandbanks; for the space of fifty miles no dry land appears on the reefs between Beaver Cay in the south and Scott's Reef in the north. This is in strong contrast to the richly vegetated cays in the (perhaps more stable) areas of Torres Strait and the Capricorns, since forest growth on a cay is a sign of maturity, then absence of trees and even of sandbanks points to a youthful stage, and may indicate that this section of the Great Barrier Reef is recovering from a drowning movement."

It may possibly have escaped consideration that the areas which are so richly vegetated in the Torres Strait are also in much closer proximity to the well-watered and luxuriant forests of New Guinea and other islands, and that the seasonal climatic changes are extremely small.

The Capricorn Group is favourably situated with regard to tidal streams and ocean currents, and flotsam is inclined to set on to these islets to probably a greater extent than between the parallels of 17°-18° and even further south.

It seems open to argument whether the forest growth on a reef is a sign of maturity or not. If by maturity is meant the completion of a cycle, then the statement is easily understood; if on the other hand age as expressed in years is intended, then it seems only reasonable to examine the character of the vegetation. Usually it is found to be soft wood, easily cut, and of no great age, also there is little evidence of former vegetation; it would appear therefore that the forest growth is not necessarily a sign of anything, except that (very likely by chance)

the particular reef has had the good fortune to receive seed, either from birds or from ocean drifts, which were able to take root and eventually spread and flourish.

It would, I imagine, be of great interest to experiment in afforestation on some of the reefs where there is at present no vegetation, and even such as are not always above water.

Occasionally one comes across a solitary mangrove growing on a reef which only uncovers at low water. In process of time it may be from this single tree others will take root and that accumulation of mud, &c., will proceed around the roots, leading ultimately to the formation of a tiny islet. The benefit of such a landmark to a seaman working in a reef-strewn area is too obvious to call for comment.

Without discussion, progress in matters of this nature is extremely difficult, and it is in the hope that these remarks may present a few points which will prove of interest to the Great Barrier Reef Committee that I have, under pressure from Mr. G. A. V. Stanley and with great diffidence, ventured to write on the subject.

REPORTS OF
GREAT BARRIER REEF COMMITTEE

VOL. II., No. 3.

# Changes at Mast Head Island

By

J. A. EDGELL, Captain, R.N.

Reprint from Reports of Great Barrier Reef Committee. Issued 27th January, 1928.

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No. 3.

## CHANGES AT MAST HEAD ISLAND.

By J. A. Edgell, Captain, R.N.

In November, 1925, a 100-feet mark was erected on the west extreme of the island and an observing platform built around it, the in-shore end of the structure being about 20 feet from the high-water line, which was fringed with casuarina trees.

The reef extends from here to the westward for about 400 yards, and is dry at low-water for about 250 yards.

On revisiting the island in August this year a considerable portion of the west side of the island was found to have been washed away, and the position of the trigonometrical station was some six feet below the high-water line and unrecoverable.

Very few of the casuarina trees were left standing, and such as remain will probably not last long.

I walked all around the island to see if a corresponding growth was manifest at any other part of its coast line, and there is no doubt that it has extended to the eastward and may continue to do so, because the land thereabouts is in general higher than the rest of the island, and as the reef extends a considerable distance to the eastward there is more protection to the land from that direction, in spite of the fact that the prevailing wind is south-easterly.

It is hoped to revisit Mast Head Island in November of this year, when a further report will be forwarded.

REPORTS OF
GREAT BARRIER REEF COMMITTEE

VOL. II., No. 4.

# The Queensland Continental Shelf

By

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Department of Geology, University of Queensland

Reprint from Reports of Great Barrier Reef Committee. Issued 27th January, 1928.

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No. 4.

## THE QUEENSLAND CONTINENTAL SHELF.

By W. H. Bryan, M.C., D.Sc. (Department of Geology, University of Queensland).

(Text-figures 1 and 2.)

### I. Advance Summary.

The following paper is admittedly of an hypothetical nature and does not pretend to be a record of new facts. Since, however, all theories dealing with the origin of the Great Barrier Reef are of necessity largely based on a consideration of the nature of the Queensland continental shelf, it appears that any contribution to a study of the latter may be of value, if only indirectly, in the chief problem which the Great Barrier Reef Committee is attempting to solve.

The author, using as his basal assumption that the 100-fathom line represents the true limit of the Queensland mass, endeavours to explain the variable breadth and strangely convex projection of the Queensland continental shelf as a natural extension of the land mass of Queensland, to the east.

The fact that the eastern edge of the continental shelf and the western edge of the highlands are symmetrical about the coast range suggests the hypothesis that the continental shelf represents the drowned half of the Queensland highlands of which the coast ranges formed the dominant axis. A consideration of the structural geology of Queensland as interpreted by the author is in harmony with this hypothesis, for the known highlands are composed of Palæozoic rocks laid down in a geosyncline, the supposed eastern edge of which approaches nearly the edge of the continental shelf.

### II. Introduction.

An analysis of the data, provided by soundings on the one hand and altitude determinations on the other, shows that the surface of the earth is made up of two rather sharply divided structural elements, one composed of large relatively smooth-bottomed depressions, and the other of somewhat smaller but less regular elevated areas. These two categories represent approximately the oceans and the continents respectively, but the coincidence is not complete for the oceanic waters not only fill the basins, but spill over the edges of the continents to a depth of approximately 100 fathoms. The 100-fathom contour thus represents the real structural limit of the continental masses, while the actual coast lines do not necessarily connote any structural significance. Although this fact is usually overlooked, the consequences are often not serious, for the 100-fathom contour is quite frequently close to and parallel with the coast line.

In the case of Queensland, where the continental shelf is of variable width and where its edge runs in directions diverse from those of the corresponding coast lines, it is of the first importance that we should realise that the 100-fathom contour represents the true edge and that the position of the coast line does not afford a safe basis for structural deductions.

If it be granted that the 100-fathom line be the true structural limit of Queensland, it should be possible to interpret the depth, extent, shape, submarine contour, and direction of outline of the continental shelf as a natural extension of the physiographic and geologic structures of that portion of the Queensland mass now above sea level.

While the shape of our continental shelf has attracted considerable attention in the past, most of the attempts to explain it seem based on the assumption that the feature is structurally incomplete and hence not to be explained as a normal structural extension of the State, but as a relic of a much larger continental shelf of uniform width.

## III. Description.

The Queensland continental shelf differs from most of the continental shelves of the world in several important respects. The chief peculiarities are (1) that its edge is much more clearly defined geographically than is usually the case; (2) it supports the greatest series of coral reefs known; (3) it shows a marked absence of parallelism with the neighbouring coast line; and (4) it varies greatly in width.

The clearness of definition is provided by the linear arrangement of the eastern edges of the almost continuous reefs which are comprehensively known as The Great Barrier Reef. As the growth of colonial corals is somewhat severely restricted by depth, they do not flourish in the relatively deep water beyond the edge of the shelf. But as the conditions of depth and the other conditions of temperature, salinity, &c., are almost ideal on the shelf itself, they grow prolifically right to the edge of the shelf, thus forming what Jukes[1] has picturesquely described as "a gigantic fortification, a steep glacis crowned with a broken parapet."

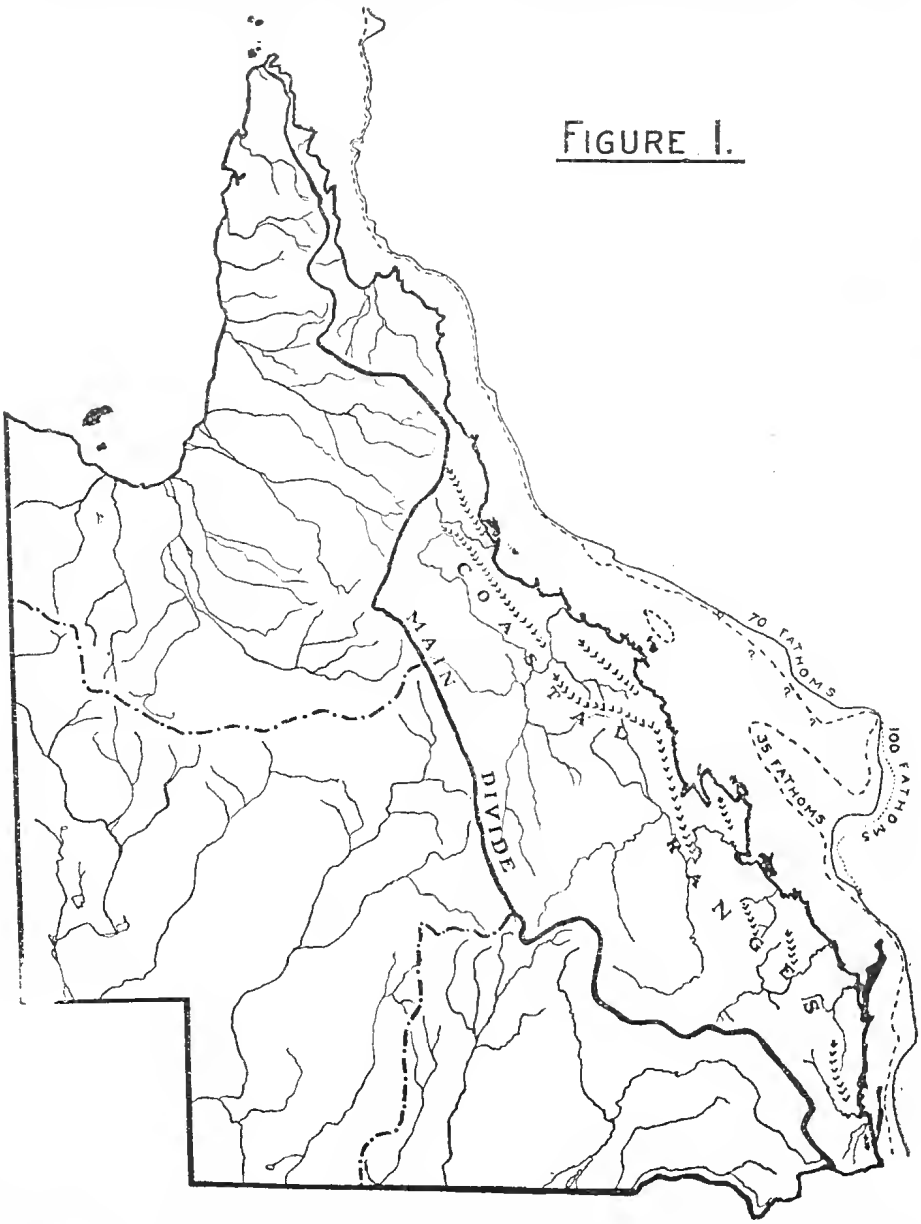
One important consequence of this has been to bring the continental shelf under the political control of Queensland, for under "*The Queensland Coast Islands Act of* 1879" the State boundary was defined as "From Sandy Cape northwards to the south-eastern limit of Great Barrier Reefs, thence following the line of the Great Barrier Reefs to their north-eastern extremity."[2]

In one important respect the State boundary departs from the structural edge of the State, and this has caused errors in the past, for several authors have published maps of Queensland in which the political

[1] Voyage of H.M.S. "Fly," Vol. I., p. 332.

[2] Votes and Proes. of Leg. Assembly, 1879.

boundary is shown, but is wrongly named, being called either "The Great Barrier Reef" or the "100-fathom line." While it is true that the State boundary, the edge of the Great Barrier Reef, and the 100-fathom contour are almost coincident from lat. 10° S. to lat. 21° S., beyond this point there are important differences. The State boundary is a straight line to the most northerly point of Fraser or Great Sandy Island, the Great Barrier Reef is represented only by isolated reefs and is in fact no longer a barrier, and the edge of the continental shelf swings in towards the coast and shows a marked embayment with its convexity




Text-fig. 1.—Showing position of so-called Main Dividing Range and Coastal Ranges.

in a north-westerly direction. This very important feature in the continental shelf is very often lost sight of as a result of this common error.

In many parts of the world the edge of the continental shelf is almost parallel with the coast line. Such an arrangement is well illustrated in New South Wales, but in Queensland no such harmony exists. A glance at the accompanying map (Figure 1) will show that although at certain selected portions, and notably in the extreme south and towards the northerly limit, parts of the continental shelf show parallelism with the adjacent coasts, yet for the greater part of its length (say from lat. 17° S. to 24° S.) the trends of the two features are divergent.

In width the continental shelf is anything but uniform, varying as it does from 15 miles in the latitude of Cape Melville to over 160 miles near Cape Manifold.

The islands of the Queensland continental shelf are remarkably numerous and are of two types:—(1) Continental islands which are usually high and adjacent to the mainland; and (2) coral islands which are only a few feet above sea level and which are usually found further from the coast line. Richards and Hedley[3], however, state that "All transitions from high coastal islands . . . to coral islands . . . may be seen."

Data concerning the nature of the material making up the continental shelf, as determined by soundings, is very meagre. A study of the Admiralty charts shows that the bottom may be composed of coral débris, of sands of varying coarseness and colour, and of mud. No systematic distribution of the several materials can be traced with the data available, but an interesting point is that quite a number of records of gravel, coarse sand, and rock appear in comparatively deep water towards the edge of the shelf.

A study of the submarine contours based on Admiralty soundings brings out a number of facts: —

1. That the 600-feet, 400-feet, and 200-feet lines are so close that the last may be regarded for most practical purposes as being coincident with the edge of the continental shelf as far south as the Barrier Reef proper extends.
2. There is a general tendency towards a parallelism of submarine features along a direction between N.W. and N.N.W.
3. A marked depression (the Capricorn Channel) starting as an embayment of the 100-fathom contour at latitude 23° S. can be traced in a north-westerly direction for a considerable distance. On the same alignment in about latitude 20° S., is an elongate basin also trending N.W. (These features are well shown by the position of the 35-fathom contour in Figure 1.)

[3] Report to Great Barrier Reef Committee, 13th July, 1923, p. 3.

4. A number of breaks in the line of the Barrier Reef provide channels in which the water is moderately deep. These channels in most cases soon cease to be well defined as one endeavours to trace them towards the west. There is no evidence of marked E.W. channels across the shelf.
5. Some of the more important of these channels where they break through the outermost portion of the barrier are between 30 and 40 fathoms deep. This feature is exhibited by the Trinity Opening (lat. 16° 20′ S.), Grafton Passage (16° 40′ S.), and Flinders Passage (18° 45′ S.).
6. Many of the outer reefs and coral islands also appear to stand upon a floor of approximately the same depth.

Several sections across the shelf have been published, notably by Agassiz[4], Vaughan[5], Richards and Hedley[6], and Paradice[7].

A study of these sections shows (1) that a considerable portion of the Queensland continental shelf can be represented as an undulating terrace about 200 ft. in depth; and (2) that the edge of the continental shelf is formed by the seaward margin of this 200-ft. terrace.

## IV. Physiographical Comparison.

Having briefly examined the Queensland continental shelf, let us now consider the adjacent portions of Queensland, and by means of comparisons endeavour to decide whether, physiographically, the portion of Queensland constituting the continental shelf may be regarded as a natural extension of the Queensland land mass.

While the position of the present coast line cannot, as has already been pointed out, be regarded as very significant, the details of its indentations should, of course, reflect the geographical trends of the State. Although the general direction of the coast from Point Danger to Cape York is approximately N. 30° W., much of the coast line is made up of longer sections more nearly meridional than this direction which alternate with shorter sections that are more nearly east and west. This alternation results in a somewhat step-like arrangement with many indentations, the openings of which are to the north. The coast line thus appears to reflect in its details a geographical trend a little west of north, across which the general direction of the coast line breaks obliquely.

In its surface relief, Queensland is naturally divisible into (1) the coastal plains, (2) the eastern highlands, (3) the western plains, and (4) the north-western plateau. The last can obviously have little bearing on the subject under discussion and so may be summarily dismissed. The remaining geographical units are prolonged in a southerly direction

[4] Bull. Mus. Comp. Zool. Harvard, Vol. XXVIII., No. 4, 1898.
[5] Smithsonian Report 1917, p. 231, Fig. 12, Sections 1-5.
[6] Trans. Roy. Geog. Soc. Qld., Vol. I., p. 26.
[7] Trans. Roy. Geog. Soc. Qld., Vol. I., p. 52.

into New South Wales, where, however, their development is in striking contrast with that in Queensland, for while in New South Wales they exhibit marked regularity of arrangement and uniformity of trend, in Queensland they are neither uniform in direction nor parallel with each other. The contrasts between the two States are well shown in any orographical map of Eastern Australia.

The coastal plains vary in breadth from a few hundred yards near Cardwell to scores of miles in Central Queensland. Vertical sections drawn at right angles to the coast line show that at many points they merge into and are continuous with the inner portion of the continental platform.

If we define the "highlands" as embracing all that part of Queensland over 1,500 ft. in altitude, they will all be included in the eastern half of the State. But, unlike their counterparts in New South Wales, they do not form a definite belt, for while at the head waters of the Mitchell River in North Queensland the western edge of the highlands, as thus defined, is only about 50 miles from the coast, in the latitude of Bundaberg it is over 350 miles from the coast.

The fact that the eastern highlands form a natural geographical unit, dominated by a north-north-westerly trend, and the manner in which this unit differs geographically from those of the surrounding regions, is indicated by any map showing the position of the principal divides and the nature of the drainage systems. (See Figure 1.) It will be seen that the rivers of Queensland fall into four distinct types of drainage, viz.—

1. Drainage into the Gulf of Carpentaria;
2. Inland drainage towards Lake Eyre;
3. Tributary drainage into the Darling River;
4. Drainage into the Pacific Ocean.

The rivers flowing into the Gulf of Carpentaria are symmetrically arranged and flow by the shortest routes in approximately straight lines from their sources to their mouths. The inland drainage towards Lake Eyre and the tributary drainage to the Condamine are also, each in its own way, examples of a normal drainage symmetrically arranged.

The rivers flowing into the Pacific Ocean are of a very different type. In place of the simplicity of arrangement found in each of the other systems and the uniformity of direction which characterised their individual streams, we have in the Pacific drainage a strange lack of system and absence of symmetry. The rivers reach the sea not by the most direct route, but only after long and tortuous passages in which it is notable that the longest sections of the streams are in well-marked valleys not normal to, but parallel with, the coast line which the rivers are trying to reach.

Thus the main features of the eastern streams resemble in a general

way the main features of the coast line in that they are made up of longer sections following the general direction of trend, alternating with and connected by shorter sections at right angles to these.

If, then, the continental shelf be considered as the natural extension of the Queensland land mass, we should expect that any topographical features which had survived the levelling action of the sea would show a marked trend in about a N.N.W. direction. This expectation is realised. The most marked feature of the submarine topography appears to be the valley-like depression known as the Capricorn Channel, which extends in a north-westerly direction for many miles. Other elongate depressions can be surmised from the incomplete data on the Admiralty charts, and these, too, show a somewhat similar direction. This submarine topography may be correlated with that of the land proper by means of the coastal channels such as The Narrows, Whitsunday Passage, Hinchinbrook Passage, &c.

We should certainly *not* in general expect to see submarine passages leading directly from the mouths of our larger rivers to breaks in the nearest portion of the Barrier Reef, nor do such channels occur. This fact was noted by Richards and Hedley[8], who state that—

> "These [openings] have been regarded by Jukes, Saville Kent, and others as marking the old entrances to the sea of the present coastal rivers. This attractive hypothesis does not bear close scrutiny, for by drawing in the contour lines from the soundings in the Admiralty charts no casual connection may be seen between these openings and the present rivers, nor may one find any evidence of defined valleys through the lagoon area corresponding in any way to the coastal rivers.
>
> "We prefer to associate these openings with the coastal valleys of the foundered strip on the edge of which now exists the Great Barrier Reef. It does not follow that each valley marked a pronounced stream channel."

Where the rivers enter the sea in a nearly meridional direction, however, we might reasonably expect to find breaks in the reef nearly in alignment with the lower portion of the river, and traces of a connecting channel between these. Thus Hedley[9] has pointed out the probable relationship of the Russell-Mulgrave valley and Trinity Passage, while Jardine[10] traces a southerly submarine prolongation of The Narrows to Curtis Channel.

It is quite possible that the more important openings of the Barrier Reef *do* represent the old mouths of the larger of our present streams, but we should expect the connecting portions of the rivers to be just as

[8] Rept. Great Barrier Reef Committee, 1923, p. 4.
[9] Trans. Roy. Geog. Soc. Qld., Vol. I., p. 69.
[10] Trans. Roy. Geog. Soc. Qld., Vol. I., p. 105.

tortuous below the present mouth as above it, if, physiographically, the continental shelf was a natural extension of our land mass to the east, and that the longer more clearly defined reaches of the drowned rivers would run not towards the edge of the shelf but parallel with it.

Although the eastern highlands form a single geographical feature, being made up for the most part of highlands and mountain ranges with a N.N.W. trend, all of which are in geographical harmony with each other, one is struck by the absence of a central dominating range. There is nothing approaching the symmetrical arrangement of the highlands about an axis, which is such a pronounced feature in most mountainous regions.

The so-called Great Dividing Range in no wise fulfils the conditions. As emphasised by Griffith Taylor, it is in no sense a range and does not constitute a geographical unit, embracing as it does ranges, plateaux, and highlands of the most varied description and diverse directions which, however, form a continuous, if irregular, divide from the Cape York Peninsula to the New South Wales border.

Again, the Great Dividing Range does not dominate the eastern highlands, for it is not within them, but approximates the western limit of their development.

But closer examination of the eastern highlands will discover the traces of what well may have been an important geographical unit in the so-called "Coastal Ranges." These form a discontinuous series of mountain ranges, including some of the highest portions of the State, which border the coastal plain from the State boundary on the south to the Cooktown hinterland on the north. Different sections of these coastal ranges have received different names, but although now discontinuous and no longer forming divides of the first importance, they exhibit by their general uniformity of trend and degree of alignment, evidence of once having formed a geographical element of great significance.

Griffith Taylor[11], it is here relevant to note, came to the conclusion that the dominating divide of the drainage system which preceded the present one was situated in approximately the position of these coast ranges. He arrived at this result from his study of the general arrangement of the present river systems and the directions of the constituent streams.

A point which has attracted a great deal of attention in the past is the shape of the Queensland continental shelf, and more particularly with that portion between the parallels of 18° and 25° south latitude. The marked convexity towards the north-east which it there displays has often been the cause of comment and several hypotheses have been

[11] The Physiography of Eastern Australia, p. 7.

invented in endeavours to explain such an unusual feature. Thus Hedley writes[12]:—

> "This widest portion I regard as a fragment left of a wide shelf which formerly continued along the whole coast. . ."

In keeping with our general policy, let us see whether it is possible to regard this protuberance as a simple feature complementary to that part of our land mass above sea-level.

A glance at Figure 1 will show that the edge of the continental shelf and the Great Dividing Range are roughly symmetrical about the present coast line. Hedley was, so far as the author is aware, the first to emphasise this point. He states[13]—

> ". . . Harmony exists between the margin of the continental shelf on the one side, and the line of the Pacific watershed on the other. Where the margin of the shelf approaches the coast so does the divide. Where the divide retreats from the shore line, so does the margin of the shelf."

But since, as the author has pointed out, neither the present coast line nor the Great Dividing Range have any real structural significance, the symmetrical arrangement appears at first to be merely an interesting coincidence.

But the coast line is not far from the coastal ranges, and the Great Dividing Range corresponds approximately to the western edge of the eastern highlands, and a statement that "the western edge of the highlands and the eastern edge of the continental platform are symmetrical about the axis of the coast ranges" may be very significant, because all are important structural lines.

If the coastal ranges form the remnants of a dominating central axis about which the highland region has been symmetrically formed, then the eastern edge of the continental shelf would mark the original limit of the region of the highlands and would thus constitute an extremely important structural line and a most likely boundary for a continental mass.

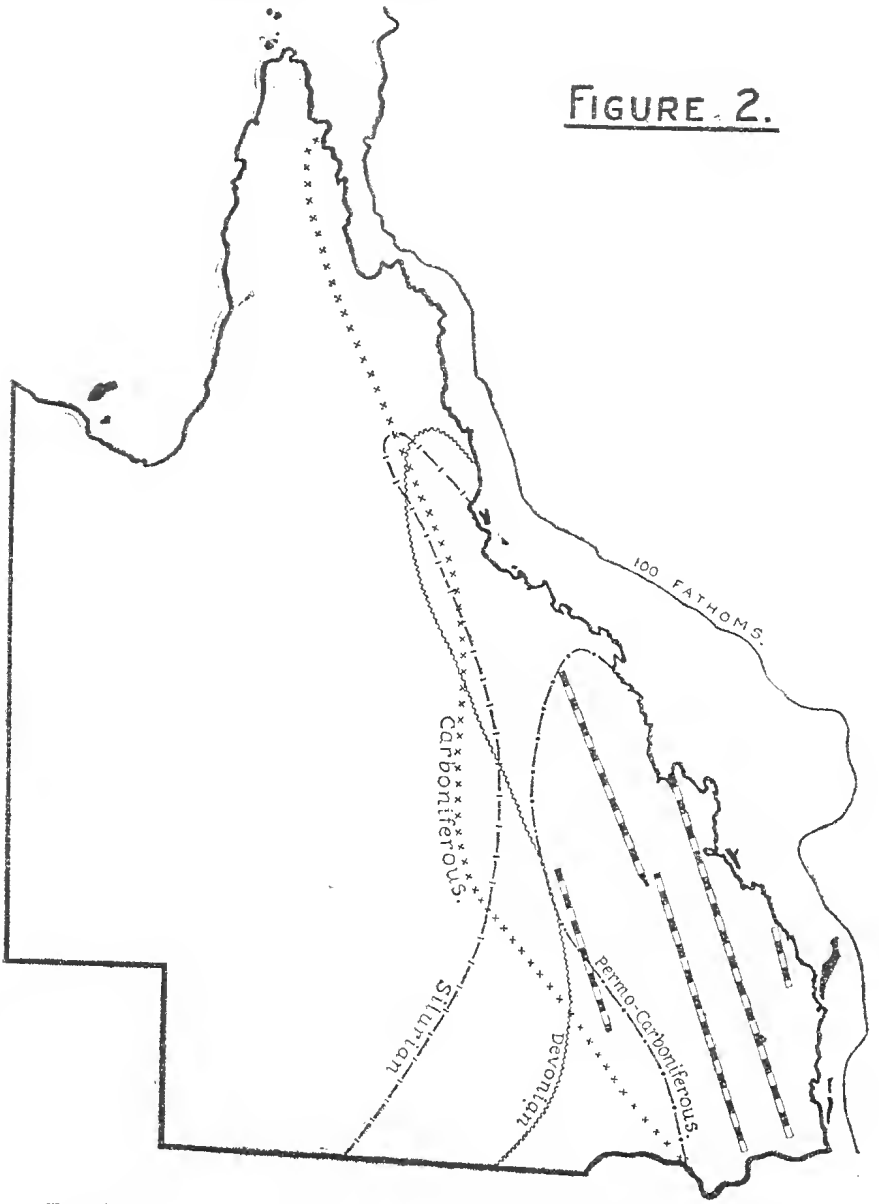
## V. Geological Interpretation.

Let us now consider to what extent the physiographic facts as set out above and the hypothetical extension of the highland region based on those facts are in harmony with the underlying geological structure of the State.

The eastern highlands are made up for the most part of Palæozoic sediments ranging in age from Silurian to Permian. These are sometimes obscured by overlying deposits of Mesozoic age or by Tertiary basalts. The marine representatives of the deposits of each of these Palæozoic periods are enclosed by the curved lines shown in Figure 2.

[12] Proc. Linn. Soc. N.S.W., 1911, p. 16.
[13] Proc. Linn. Soc. N.S.W., 1911, p. 37.

The similarity in shape of the enclosed areas representing the several periods suggests that each of the Palæozoic deposits was laid down in the same elongate depression in a direction N. 30° W.




Text-fig. 2.—Showing positions of geosynclinal seas and anticlinal axes.

The author has urged elsewhere[14] this view that the Palæozoic sediments of Eastern Queensland were deposited in an elongate geosyncline, the eastern limit of which was formed by the ancient now-vanished land of "Tasmantis." This "Tasman geosyncline" he

[14] Proc. Roy. Soc. Qld., 1926, p. 93.

regarded as the most important geographical feature of Australia in Palæozoic times. In the light of this hypothesis, the author published a series of Palæogeographic maps in which the western boundaries of the geosyncline appeared in the positions which they now occupy in Figure 2 [15], and in which the supposed eastern boundaries were drawn roughly symmetrical with the western in accordance with the author's conception of the probable shape of the geosyncline. Although the possible significance of it escaped the writer at the time, it is interesting to note that most of these supposed eastern limits of the geosyncline approach quite nearly the edge of the present continental shelf. (The Permo-Carboniferous geosyncline is a considerably shrunken area when compared with those of the preceding periods, and forms a natural connecting link between Palæozoic geography and the influence which was still exercised by the old geosyncline on the one hand, and the Mesozoic and its extensive lacustrine deposits on the other[16].)

The thought now presents itself that if the edge of the continental shelf does represent the eastern limit of the highland region (as the physiographical study suggested) then as the highlands are made up of the Palæozoic rocks of the Tasman geosyncline, the continental shelf is also made up of Palæozoic rocks whose eastern limit is marked by the 100-fathom contour. The edge of the continental shelf may then represent the eastern edge of the Tasman geosyncline. If this be so, the continental edge reflects in its position and trend a very ancient and highly important structural and geographical line.

The relationship of the underlying geological structure to the pronounced geographical trend to the N.N.W. (which is the most distinct characteristic of the streams, mountains, and coast line of Eastern Queensland) is a very direct and a very marked one.

Throughout the geological history of Eastern Australia, the best known earth movements have been along N.N.W. axes, with the result that this direction is the prevailing strike in the folded sediments and is necessarily reflected in the topography of the surface. Further, since the folding has been severe, especially along certain lines, the affected beds are steeply dipping, and the opportunities for differential erosion thereby enhanced. Thus long "strike" valleys containing "subsequent" streams are developed in the softer rocks. And since, generally, the newer rocks are softer than the old, the latter are left as strike ridges. As the result of considerable study of these facts in the field, the writer strongly supports Marks[17] in his contention that the degree of dependence of the geographical features on the underlying geological structures in Eastern Queensland has not been sufficiently appreciated in the past.

At the end of the Mesozoic era an epoch of strong crustal folding was inaugurated in Eastern Queensland and, as so often happens, the

[15] Proc. Roy. Soc. Qld., 1926, Text-figs. 3-6.
[16] Proc. Roy. Soc. Qld., 1926, p. 98.
[17] Proc. Roy. Soc. Qld., 1924, p. 14.

part principally affected was the important geosynclinal area of a former time. The Palæozoic sediments of the Tasman geosyncline were folded along a series of N.N.W. axes and produced what the author has termed elsewhere the "Great East Queensland geanticline"[18]. The more important structural lines of this great geanticline are shown in Figure 2, and their relationship to the geographical trends is obvious.

If the author's hypothesis represent the truth, and the eastern edge of the continental shelf be indeed the margin of an old highland region and the approximate boundary of the "Tasman geosyncline," then it would be reasonable to suppose that the portion now forming the continental shelf was also folded along N.N.W. lines, but, unfortunately, there is no direct evidence whatever as to the geological nature of the foundation of the continental shelf. But as the topography of the highlands reflects the underlying geological structure, so may the submarine topography of the continental shelf be a guide to the underlying geological structure. Thus the wide valley-like depression of the Capricorn Channel might represent a northerly extension of the soft Mesozoic rocks of the Maryborough basin. This would explain the fact that from Sandy Cape to Cape Capricorn there is a complete absence of continental islands. Again, it would provide us with a plausible reason for the marked alteration in depth as shown by soundings in the neighbouring portion of the continental shelf, the not infrequent earthquakes in that region, and the breaking of the submarine cable, as results brought about by the sliding and faulting of the comparatively weak Mesozoic rocks away from the continental shelf. On the other hand, Swain's reefs may rest on a massive and an enduring foundation of Silurian and Devonian rocks.

[18] Proc. Roy. Soc. Qld., 1925, p. 35, fig. 3.

# REPORTS OF GREAT BARRIER REEF COMMITTEE

VOL. II., No. 5.

# The Topography of the Townsville Littoral

By

F. JARDINE, B.Sc.

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No. 5.

# THE TOPOGRAPHY OF THE TOWNSVILLE LITTORAL.

By F. Jardine, B.Sc.

(Plates I. to III. and Text-figures 1 to 4.)

## Introductory.

The following notes comprise descriptions of the salient features of the littoral strip extending from a point about 18 miles west of Townsville to the mouth of the Burdekin River about 80 miles to the south-east. The physiographic features of this area fall naturally into four divisions, viz.—the tableland on the west, the coast alluvial deposits, the residuals rising through the alluvium, the islands and tied-on islands of the shore line.

## General.

The shore line has a general trend from slightly south of east to north of west. Its linearity is broken by the projections Cape Bowling Green and Cape Cleveland, which confine Bowling Green Bay. Cleveland Bay occurs on the western side of Cape Cleveland, and is partly enclosed by Magnetic Island on the west. The tableland scarp in the north is distant about 14 miles from the shore line, but to the south is distant over 50 miles. The coastal belt, composed of alluvium through which rise numerous inliers, slopes from an elevation of a few hundred feet at the foot of the tableland scarp, to sea level, and is drained by numerous stream courses, the general directions of flow of which are from south to north.

## The Tableland Scarp.

The tableland scarp, which is named successively from north to south Paluma, Hervey, and Leichhardt ranges, attains an elevation varying from 3,000 ft. to 1,000 ft., and is composed, with the exception of certain restricted areas in the headwater region of the Black, Ross, Bohle, and Houghton rivers, of granite. The scarp is in parts elaborately dissected, and the coastal streams occupy well-defined notches, which are important lines of communication with the tableland. The railway ascends the notch cut by the Houghton River, while the Georgetown road utilises that cut by the Black River. The tableland surface on the eastern margin is more or less mature, consisting of a shallowly dissected surface with fairly low scattered residuals which bound the tableland stream basins. The scarp ranges, the main water partings, are often several hundred feet above the general tableland surface, due to erosion effected by the tableland streams. Where the Georgetown road passes on to the tableland (over a coarse biotite granite with abundant basic segregations, which is traversed by aplite and fine-grained red granite),

the tableland has been deeply dissected and the foot hills extend for some distance between the watersheds of the Black River and Bluewater Creek.

### Residuals.

From the summit of Mount Matthew (1,028 ft.), the highest point in the Muntalunga Range, lying about 9 miles south-east of Townsville, an excellent idea of the topography of this area may be gained. North-westward, the dominating feature is the almost plane surface of the coastal plain. This is sparsely timbered on the west; thin scrub and grass lands on the east are succeeded by salt pans, the latter shut off from the sea by a somewhat denser narrow belt of timber. In the foreground are three low knolls of rounded outline 50 ft.–100 ft. in elevation, isolated from the main slopes of Mount Matthew, which northward slopes steeply to become buried in the alluvium of the plain. In the middle distance Townsville nestles about the foot of Castle Hill, which rises to 933 ft., and the town extends south-westward towards Mount Louisa, a low ridge rising to 665 ft. four miles distant. Behind Castle Hill the broken summits of the Many Peaks Range are seen culminating in Cape Pallarenda, about 6 miles north-west of Townsville, while northward from this range the rugged granite outline of Magnetic Island rises almost 2,000 ft. above sea level. Looking towards the north-east from Mount Matthew, the delta and distributary streams of Alligator and Crocodile Creeks dissect the coastal plain in a gleaming fretwork design. To the west the town of Stuart nestles in the pocket cut by Stuart Creek, and is overlooked by Mount Stuart, which rises almost 2,000 ft. above the plain. The Mount Matthew Range is the most northerly of a very curious group of residuals comprising the Mount Stuart, Mount Matthew, The Sisters, and Mount Elliot groups, enclosed by the Ross River on the west and the Houghton River on the east. This somewhat wedge-shaped group culminates in the rugged Mount Elliot group, which attains an altitude of 3,980 ft. immediately south of Cape Cleveland. This mass is subdivided into various groups by a series of valleys, which are occupied by streams. The Mount Stuart group is cut off from The Sisters group by the valley occupied by Stuart Creek. The Muntalunga Range is isolated from The Sisters group by a valley partly occupied by White Creek, a tributary of Alligator Creek, while the Mount Elliot group is isolated by the notches cut by Alligator Creek flowing to the northward and the Antill Plains Creek, which flows westward to the Ross River. The outer slopes of these residuals fall steeply to become buried beneath the alluvium of the plain. The Great Northern Railway (passing on to the Tableland) passes through these residuals by way of the Stuart Creek valley, while the North Coast Railway passes down the valley which isolates the Mount Matthew Range, and this obviates the crossing of the salt pans and numerous distributary streams of Alligator and Crocodile Creeks.

The narrow coastal strip between the Burdekin and Houghton Rivers is practically a plane surface with but few isolated residuals.

## Detailed Description of Residuals.

### *Mount Louisa.*

Mount Louisa is a low ridge, rising to 660 ft., trending for two miles in an east-west direction, distant about four miles south-east of Townsville. The eastern slopes of the ridge are encircled by Louisa Creek, which empties on to the salt pans at Townsville West. The alluvial deposits at the base of the hills attain an altitude of 32 ft. above sea level, and Louisa Creek is intrenched in the silts to the extent of 20 ft. On the eastern flanks of the hills, at the base, the rock is brecciated, consisting in parts of angular fragments of quartz-felspar porphyry cemented in a fine-grained matrix exhibiting traces of fluidal structure. The rock is traversed by dykes of a greenish-grey porphyrite. The brecciated material passes into a greenish silicious tuff which is considerably shattered, the joint plane striking W. 35° S. and dipping in the north-west quadrant at 50°. Towards the summit of the hill a fine-grained pink felspar porphyry passes into a granite porphyry.

### *Mount Bohle.*

The Mount Louisa Range is flanked on the west by the Bohle River, and the valley of this stream cuts off the Mount Bohle Ridge (346 ft.), the prolongation of the Mount Louisa Range to the west, extending also for about two miles. This elevation consists of a finely banded silicious rock, which in places appears to be of the nature of a sheared quartzite with intruded quartz veins, while higher on the hill slope the rock appears to be a silicious sinter, closely resembling certain rocks of the Many Peaks Range.

The rocks of the Mount Louisa and Mount Bohle ridges are considered to belong to the Upper Bowen division of the Permo-Carboniferous series (Jack).

### *Muntalunga Range.*

The Muntalunga Range is a somewhat S-shaped group of hills, the highest point in which is Mount Matthew (1,028 feet), about eight miles south-east of Townsville. As previously pointed out, this group of hills is merely isolated from a complex of residuals by a broad valley occupied by White Creek. The divide between White Creek (flowing to Alligator Creek) and Sandfly Creek (flowing to Cleveland Bay) attains an altitude of only 120 feet. The valley floor consists largely of gravels and silt. In these, White Creek, which is fringed by restricted flood terraces, is intrenched to the extent of 20 feet.

On the western foothills of Mount Matthew a sheared brecciated felspar porphyry traversed by numerous dykes of porphyrite occurs. Ascending the mountain, felspar porphyry and granite porphyry occur alternately, and these also are traversed by dykes of porphyrite. From Mount Matthew the hills subside fairly rapidly; the eastern flanks, which consist of a line of low hills, terminate on the left bank of Alligator Creek.

*Mount Stuart Range.*

The precipitous northern summit of Mount Stuart (1,921 feet) is an arresting feature of the topographic forms in the vicinity of Townsville. This range is roughly semicircular in outline, with convexity directed slightly west of north. The residual is broad and in places fairly flat-topped. The western flanks of the hills occupy the angle formed by the Ross River, where it changes its north-south course for a north-east course to the sea. The eastern hills sweep round to Stuart Creek, which isolates this group from the Sisters residuals. In ascending Mount Stuart from the north the writer encountered in the foothills fine- and coarse-grained acid granites, aplites, and porphyry; at 200 feet, quartzite occurred, characterised by a *lit-par-lit* intrusion of silica. At the base of the rise to Mount Stuart and for 1,300 feet, fine- and coarse-grained pink granites were traversed. Towards the summit, syenite occurred, succeeded by a pink granite which forms the northern mountain cliffs.

On the eastern flank of the mountain, in the valley of Stuart Creek, the railway cuttings expose beds of the Upper Bowen formation; these consist of sandstone, conglomerates, carbonaceous shales with intercalated lava flows; occasionally narrow seams of coal occur. These beds, considered from the evidence of boring to have a thickness of about 350 feet, are intruded by granite and porphyry. (Jack.)

*The Sisters Group.*

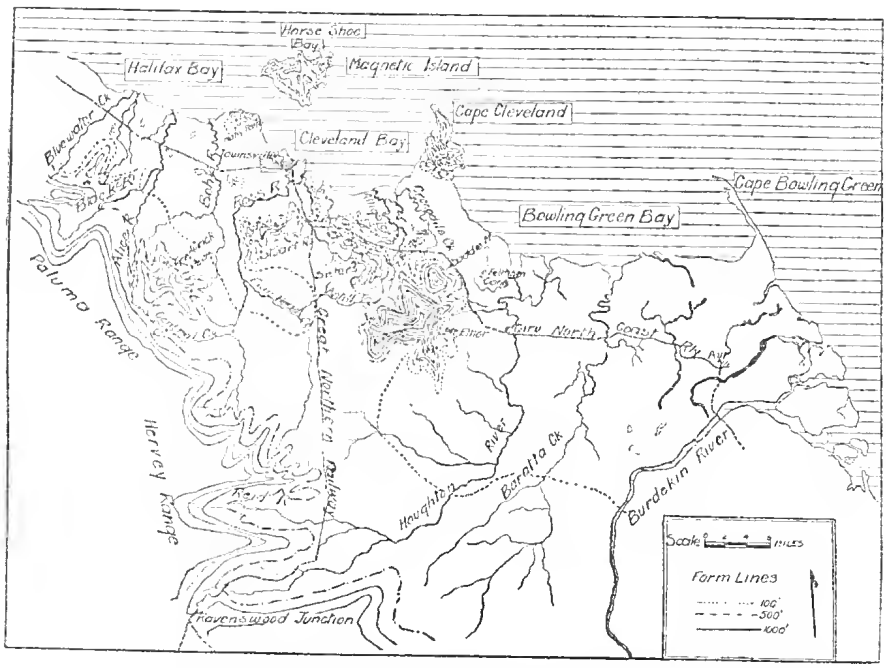
This somewhat irregular mass of residuals roughly forms an arc of low curvature, the convexity of which is directed towards the north-east. The group terminates roughly at Stuart on the north-west, and at the col formed by the headwaters of Antill and Alligator Creeks on the south-east. The Sisters Mountains constitute a broad flat-topped group rising to over 1,000 feet at the south-east extremity; towards the north-west the hills are low knolls overlooking the town of Stuart (Stewart's Creek Station on the North Coast Railway). The dissection of the highlands has been such that resulting topography is rugged; steeply falling gorges fall to broad flats, which penetrate the highlands. Indeed, the smaller hills often rise extremely steeply, culminating in sharp crests or pinnacles. These variations appear to be due to differences in rock composition resulting in differential erosion.

South-west from Nome, on the North Coast Railway, the hills are composed of fine-grained chocolate and grey vesicular and amygdaloidal lavas, with well defined flow structure. These lavas are mentioned by Jack and Etheridge on page 173 of "The Geology and Palæontology of Queensland," and are considered to be a continuation of the Stuart Creek beds. These rocks give place to granite and porphyries on the south-east.

*Saddle Mountain—Mount Elliot Group.*

The extraordinarily high southern group of residuals include Saddle Mountain (2,847 feet) with several unnamed peaks over 2,000 feet high, Mount Elliot (3,980 feet), Shoulder Mountain (3,472 feet), Sharp Elliot

(3,810 feet). The Saddle Mountain group is more or less isolated from the Elliot group by notches cut by Alligator Creek on the north-west, and by St. Margaret Creek on the south-east. The area is extremely rugged, the streams occupy steeply falling narrow gorges, and the mountains slope precipitously to the encircling alluvial plains. Marked features of the topography are the broad alluvial flats which penetrate into the highlands, and form the valley floors through which the streams, after falling steeply from the mountain slopes, meander to the sea. The broad valley of Killymoon Creek, a tributary of Crocodile Creek, isolates a narrow steep spur (800 feet) from the main mass, and forms the




Text-fig. 1.—The drainage of the Area. The form lines are merely sketched in to indicate, broadly, the topography.

lateral divide between this creek and Alligator Creek on the west. This spur is prolonged northward to Woodstock Hill (756 feet). The continuity of this line is, however, broken by two gaps, through the southern of which the North Coast Railway, after passing down the valley of White Creek and crossing Alligator Creek, passes to hug the flats at the base of Saddle Mountain; Woodstock Hill is itself isolated completely from the spur by intervening salt pans. North of the railway gap the hills are composed of felspar porphyry, fine-grained granite and quartz-felspar porphyry traversed by porphyrite dykes. Traversing the southern hills from the north aplitic granite, granite porphyry, felspar porphyry, and limited areas of coarse biotite granite and porphyrite dykes were encountered. The writer ascended to an elevation of 2,400 feet on Saddle Mountain over a coarse light-grey biotite-hornblende

granite. About 4 miles south-east of Clevedon, at the foot of Saddle Mountain, quartzite and felspar porphyry occur, outcropping on the hillside. The Mount Elliot group, presumably, is also composed largely of granite. The writer did not ascend the mountain, but specimens of the granite from the group have been described by Jack.

*Mount Landers.*

This is a low hill rising to about 400 feet through the Antill Plains. It is composed of fine- and coarse-grained red granite traversed by dykes of porphyrite.

Many residuals occur in this area. All were not visited by the writer, but are indicated on the map (Figure 1). The Cone (315 feet) and Feltham Cone (927 feet), which rise through the salt pans west of Houghton River, were inaccessible, being isolated by salt marshes and tidal creeks. Mount Low, situated between the mouths of Bohle and Black Rivers, and Mount Saunders north-west of Yabulu on the North Coast Railway, were not visited. On the other hand various residuals unmarked on the county map were examined.

At Kulburn, on the North Coast Railway, 12 miles west of Townsville, a low ridge 200 feet high occurs south of the railway line on the right bank of the Black River, and is composed of granite porphyry and fine-grained red granite. About 8 miles south-west from Ayr, three small detached hills rise through the silts to about 200 feet, and are composed, respectively, of a medium-grained acid granite, and a pale acid granite containing muscovite and biotite.

## Shore Line Residuals.

*General.*

Cleveland Bay is bounded on the east by Cape Cleveland, an area of dissected high ground rising to 2,000 feet, and is enclosed on the west by Magnetic Island and the outjutting Many Peaks Range, from which Magnetic Island is distant about 4 miles to the north-west. A small indentation in the bay bounded by Cape Pallarenda on the west and the Castle Hill projection on the east is named Rowe's Bay (after the pioneer, Mr. C. S. Rowe, and is erroneously marked on the Admiralty charts and county maps as Rose Bay). Bowling Green Bay is limited on the east by Cape Bowling Green, which differs from Cape Cleveland in that it is merely a low narrow strip of alluvium of the nature of a spit somewhat recurved to the north. From evidence which is adduced later, it is clear that the Many Peaks Range, Cape Cleveland residuals, and Castle Hill have been tied on to the mainland by a slight negative movement of sea-level.

*Many Peaks Range.*

The Many Peaks Range rises to 721 feet in Mount Marlowe, 5 miles north-east of Townsville. The range extends for about 3 miles in the form of an arc of slight curvature, terminating in Cape Pallarenda.

The eastern part of the range at its base is composed of tuffs which, in the ascent, give place to a fine-grained quartzite and a siliceous sinter-like rock, succeeded by tuffs. Intrusions of granite porphyry and felspar porphyry occur towards the summit; finally one passes from quartzite on to a fine-grained pink granite at the summit of Mount Marlowe. The dip is not discernible in the quartzite. The granite is jointed, the planes strike N. 10° W., and dip toward the north at 62 .

There are apparent, on the eastern and south-eastern hill slopes, which are some little distance from the present shore line, some traces of faceting, but the evidence is not very satisfactory, for the rocks are not competent to reflect evidences of a strand line.

### *Castle Hill.*

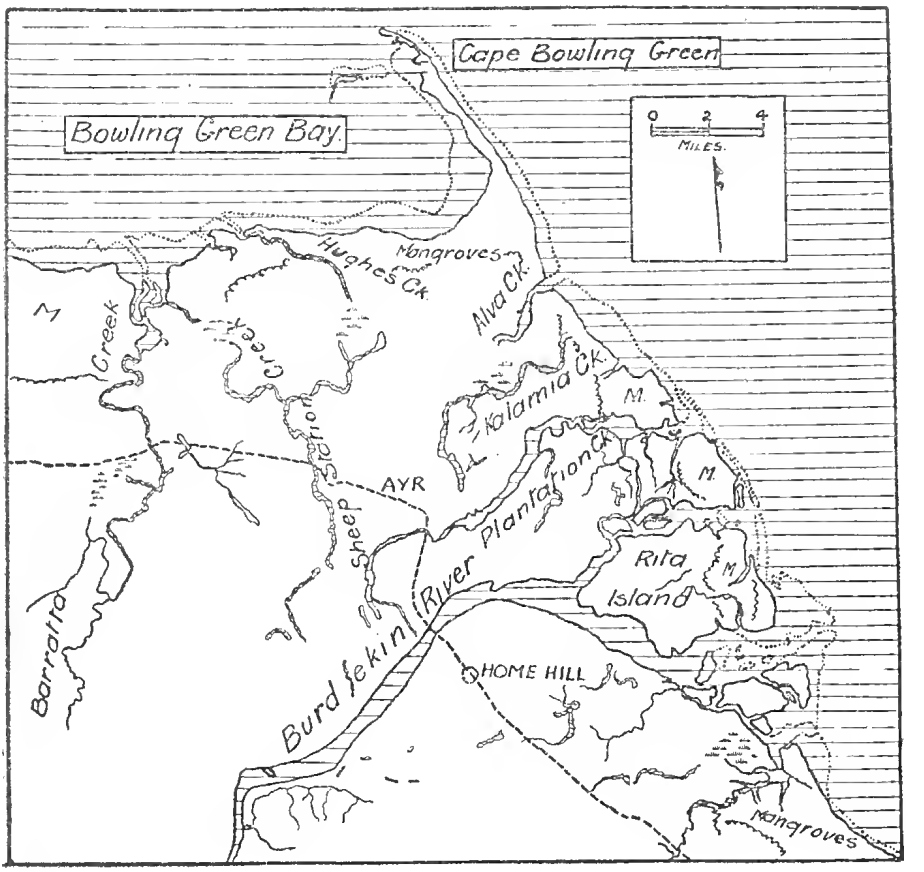
Castle Hill, or Mount Cudtheringa, rises to 933 feet at the mouth of Ross Creek on the west. The hill is composed of pink acid granite and porphyry, strongly and variously jointed, traversed by more basic dykes of porphyrite. On the north-east aspect the hill slope is precipitous towards the summit, but elsewhere the slope is fairly gentle, though rugged, to the plain. Melton Hill is a low spur jutting towards the north-east, culminating in Flagstaff Hill and Magazine Island. A rocky connecting bar across Ross Creek has been removed for navigational purposes. Kissing Point, or Red Cliff Point, marks a further ridge, 60 feet high, towards the north-west, isolated from the main hill by a low neck of "made ground." Here the fine-grained acid granite is strongly jointed, the joint planes striking W. 10° N., and north and south. On the seaward side bluffs occur, but no trace of shore line emergence was observed.

About 1 mile west of the town, a knoll known, the writer believes, as Jimmy's Lookout, rises to 100 feet above the flats. This hill is composed of a ferruginous quartz porphyry.

### Cape Cleveland Residuals.

The Cape Cleveland residuals form a triangular mass about 7 miles long in a north-south direction and 4 miles broad in an east-west direction. The residuals are highest in the south, where they attain altitudes of 1,500 feet to 2,000 feet. Northward, the residuals terminate in a low projection 150 feet high, upon which the lighthouse is situated. The topography is extremely rugged. The highlands are considerably notched by steeply falling streams which empty on to comparatively broad alluvial fringing flats, merely a few feet above sea level. A broad notch which practically bisects the hills has been cut by streams, one flowing to the north-west, the other to the south-east. On the eastern and western margins towards the south, the hills are fringed by restricted areas of coastal flats through which streams flow intermittently. Towards

the north the hills fall steeply to the sea. On the south the hills fall steeply to the salt pans and flats which extend for about 6 miles to Woodstock Hill.




Text-fig. 2.—The Burdekin Delta.

The southern and south-eastern hills of the Cleveland residuals are composed of a coarse-grained biotite-hornblende granite, which is, in places, porphyritic. The granite is traversed by numerous aplite veins and dykes which strike E. 30° N. and north and south along joint planes which dip vertically. A small isolated hill on the south-west is composed of a pale gneissic granite. Proceeding along the eastern shore of the headland, towards the north, the character of the rock remains unchanged for some distance. About 1 mile south of the lighthouse a medium-grained acid granite occurs strongly jointed. The joint planes strike north and south and dip eastward at 75°. This rock intrudes, in a series of broad dykes, into thick beds of banded quartzites which strike W. 15° S. and dip towards the south-east at 55°. The latter rock is also strongly jointed; the joint planes strike N. 20° W. and dip towards the south-west. The quartzite, at first medium-grained, passes into a very coarse

granular rock, and from this point northward coarse- and fine-grained rocks alternate with occasional bands of sheared quartz conglomerate. Towards the northern boundary of the quartzite, the rocks strike W. 10° N. and dip towards the south-west at 35°. About half a mile south of the lighthouse the quartzites are succeeded by a banded hornfels rock, followed by a conglomeratic rock, and finally an extremely fine-grained hornfels.

These rocks, as well as those occurring on the western extremity of Magnetic Island, in the Many Peaks Range, Mount Louisa, and Stuart Creek, are mentioned by Jack as belonging to the Upper Bowen series.

## Magnetic Island.

Magnetic Island is roughly triangular in outline, the base of the triangle measuring about 7 miles. The apex is directed southward. The topography is rugged, consisting of central radiating axes of granite, varying in altitude from 1,000 to 1,500 feet, which fall steeply to the sea in rugged headlands. The geology of the island has been discussed by Mr. A. Gibb-Maitland. The south-western shore of the island is linear, and consists of a narrow fringing mangrove-clothed coastal plain. The northern shore line is broken by projecting headlands which form two comparatively shallow indentations, and at the heads of these indentations, alluvial flats extend to the granite ridges.

The south-eastern shoreline is less linear, being broken into a series of coves and shallow bays by fairly low projecting granite headlands. Invariably the cove-heads are fringed by low flats, which extend sometimes for a considerable distance towards the interior of the island. The granites of the island are strongly jointed, but no trace of benches in the headlands was observed by the writer; it is from the evidence of the bay-head and cove-head flats that a movement of emergence of the land relative to sea-level may be deduced.

### *Horseshoe Bay.*

Horseshoe Bay occurs on the northern side of the island. The bay is about 1½ miles broad and is fringed by a broad flat extending for 1 mile to the granite hills which here divide the north and south flowing waters. Endeavour Creek empties into the south-west corner of the bay, after flowing parallel to the shore for some little distance. Towards the east, a shallow lagoon has an outlet to a mangrove-fringed creek which flows parallel to the shore, finally emptying its waters into the bay towards the east. The flats at the foot of the hills to the south attain an elevation of 50 feet above high-water level, and are composed of a loose granite gravel derived from the weathering of the hill slopes. From this point the flats slope gradually down to 10 feet above sea-level, and are composed of a black and greyish clay, and finally a loam. The flats are well grassed and timbered. The approach to the shore is cut off by a belt

of sand dunes about 100 yards broad. Scattered through this wind-drifted material, roundish boulders of granite, large fragments of pumice, and massive blocks of coral occur.

*Geoffrey Bay.*

In the south-eastern shore line Alma Bay is separated from Geoffrey Bay by Bremner Point, a tied-on ridge of granite. The alluvial flats are continuous from the head of Alma Bay to Bright Point, the southern extremity of Geoffrey Bay. These flats attain a maximum width of about a quarter of a mile, and are composed mainly of loose sand, scattered throughout which are abundant large pumice fragments, blocks of coral, and numerous shells. The loose material is becoming fixed by grasses and creepers, and above the beach, towards the south, the loose sand has been thrown into a series of low wrinkles by wind action.

*Nelly Bay.*

The flats at the head of Nelly Bay extend for a considerable distance towards the interior of the island in the form of a V. Gustav Creek empties on to salt pans, finally reaching the sea after flowing parallel to the shore for a short distance. The flats here gradually rise from 15 feet above sea-level towards the interior, and are cut off by an area of drift sand which fringes the bay, particularly on the southern shores.

*Picnic Bay.*

The flats fringing Picnic Bay slope from 40 feet above sea-level at the foot of the hills, to 20 feet above high-water level. A stream is intrenched to the extent of 20 feet in these flats, here composed of granite gravel.

* * * * * *

The altitude of these flats, the presence in the alluvial materials of granite boulders, blocks of coral and pumice (which cannot be wind-drifted material), the intrenchments of the stream in the alluvial deposits, clearly indicate an emergence of the land relative to the sea of about 20 feet.

STREAMS OF THE AREA.

The rivers of the area described (with the exception of the Burdekin, of which the writer is acquainted with only the lower 35 miles), exhibit a remarkable uniformity in characteristics, and there are few deviations from normal features.

West of Cape Pallarenda, Bluewater Creek, the Black–Alice, and Bohle Rivers empty their waters into Halifax Bay; Ross River, Alligator, and Crocodile Creeks drain to Cleveland Bay; the Houghton River and Barratta Creek waters reach Bowling Green Bay, and finally the Burdekin waters reach the sea in Upstart Bay, east of Cape Bowling Green.

The streams have a general north-south trend, but there is a tendency, particularly the headwater courses, to flow on a south-west to north-east course. This is apparent in the case of the Black River, Little Bohle River, the Ross River (in the case of Central Creek), and markedly in the Houghton River.

The juxtaposition of an abrupt scarp on the one hand and an alluvial plain on the other, is reflected in the stream profiles, which are juvenile in the extreme headwater region and mature in the lower courses. There is a marked absence of uniformity in the extent of erosion effected by the streams in the tableland scarp, and it is only in the headwater regions that the true lateral divides separate individual stream basins. The notches are characteristically broad, with level alluvium-filled bottoms, and though this alluvial material attains an altitude of 250 feet above sea-level, the streams occupying the notches are rarely intrenched to an extent greater than 50 feet.

At the river mouths estuarine conditions prevail, and the streams invariably reach the sea by way of delta lands. After falling from the tableland, the streams spill out in the porous gravels and silts of the plain, and as a consequence the river beds are dry and are characterised by the presence of flood terraces, &c.

A characteristic of many of the dry stream courses is the occurrence locally in the river beds of a rock composed of consolidated river gravels, &c. This occurrence recalls that of beach rock. In this case, however, the consolidation appears to be due to capillarity and evaporation.

In the north, Bluewater Creek, Black–Alice, and Bohle Rivers are short streams falling from the Paluma Range. In the headwater region the Black River flows for about 8 miles to the south-east, parallel to the tableland scarp through dissected country. It then turns sharply towards the north-east and is joined by the Alice River about 6 miles from the sea. The latter rises is a gorge which, with that cut by Central Creek, isolates the Frederick Peak massif from the Hervey Range. About 4 miles upstream at Kulburn, the silts attain an altitude of 40 feet, and the stream is here intrenched to a depth of 20 feet. At a point 12 miles upstream, the Alice has incised for 30 feet in coarse gravels which are here about 100 feet above sea-level. About 3 miles from the tableland scarp, Log Creek, a tributary of the Black River, flows through silts which are elevated 280 feet above sea-level, and this stream has excavated a trench only 25 feet deep in coarse gravels.

The Bohle and Little Bohle Rivers rise on the northern slopes of the Frederick Peak massif. The Little Bohle flows towards the north-east to join the Bohle, which flows towards the north, and enters the sea west of the Many Peaks Range. At a point 7 miles upstream, the river level is about 20 feet below that of the plain, here 30 feet above sea-level; 12 miles upstream the alluvial material attains an altitude of 160 feet,

and here the stream bed is 20 feet lower. About 19 miles upstream the Little Bohle is intrenched to the extent of 25 feet in the alluvium, which is 250 feet approximately above sea-level.

The Ross River flows north from the Hervey Range for about 20 miles, receiving on its left bank Central Creek, and on its right bank Five Head Creek, which, as Antill Creek, rises on the southern slopes of The Sisters residuals and drains the plain south of the Stuart residuals; the river then flows towards the north-east rounding the Stuart residuals, bifurcates about 3 miles from the sea, and isolates Ross Island. The left arm, known as Ross Creek, fringes Castle Hill on the east. Stuart Creek enters Ross River 1 mile from the river mouth. Where the river turns sharply to the north-east it is distant somewhat less than 2 miles from the Bohle, and it is noticeable that the upper Ross and lower Bohle are co-linear, and the divide between these streams is a plane surface. It is probable that the upper Ross River formerly formed the headwaters of the Bohle River.

About 5 miles upstream, at the Ross River meatworks, the Ross is intrenched to the extent of 15 feet in the silts; about 7 miles upstream the river bed (here dry) is 28 feet below the surface of the plain. About 8 miles upstream advantage has been taken of a bar of granite porphyry, which outcrops in the bed of the stream, to construct a weir across the river. Here the alluvium is 50 feet above sea-level and the stream bed is 20 feet lower. At a point 16 miles upstream, the river is intrenched to the extent of 40 feet in the silts, which are, at this point, 150 feet above sea-level. At the junction of Round Mountain Creek and Ross River the flats attain an altitude of 170 feet. Passing to Central Creek, the flats at the foot of the tableland attain an elevation of 260 feet above sea-level; the stream intrenchment here does not exceed 50 feet.

Stuart Creek, at the railway station called Stewart's Creek, is intrenched about 40 feet in the silts, which are elevated 55 feet above the sea.

The Houghton River rises in a large notch in the tableland scarp south of the Ross River headwaters. From this point the river flows north-east, draining that broad expanse of plain bounded on the north by the Mount Elliot residuals and on the south by the tableland scarp. In the head-water tract the river receives the large Reid River tributary. After flowing for 36 miles on a general north-east course the stream turns north and meanders for 28 miles across the plain to the sea. Both the Reid and Houghton Rivers in their upper courses drain broad alluvial flats which attain elevations of 250 feet to 270 feet. In these flats the streams are intrenched to the extent of 60 feet to 80 feet.

The Houghton River enters the sea by way of extensive delta lands. About 2 miles south of Giru the flats are 15 feet above sea-level, and in these the Houghton is intrenched to the extent of 12 feet. The littoral strip east of the Mount Elliot group of residuals is characterised by the

presence of vast swampy depressions, connected by broad channels which distribute the river flood waters over a large area of country. A few miles below the point where Major Creek (which rises in the southern slopes of Mount Elliot) joins the Houghton, flood distributary channels from the river feed extensive swamps and lagoons to the east of the Saddle–Elliot group, finally rejoining the Houghton by way of Burrum-bush Creek at the river mouth, where there is an extensive development of mangrove swamps. A smaller chain of lagoons and swamps encircles Giru on the North Coast Railway.

There is a similar development of swamps and distributaries fringing Barratta Creek, which also meanders to the sea by way of extensive mangrove swamps.

The writer has examined only the lower 35 miles of the Burdekin River, and the description is therefore confined to that area.

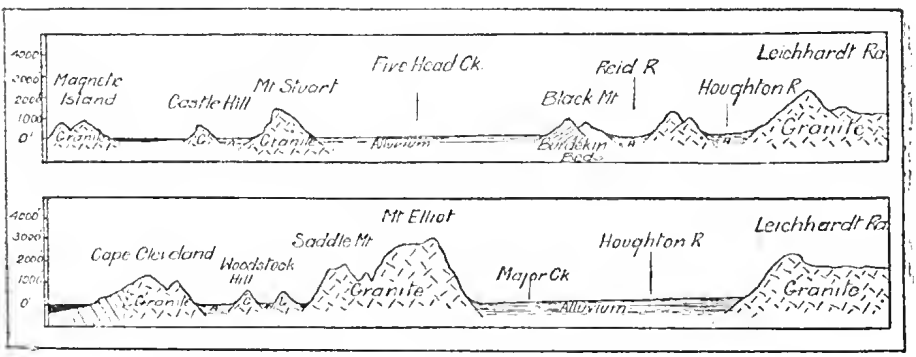
At Clare, some 30 miles upstream, the alluvium of the plain attains an elevation of 160 feet above sea-level, and in this the Burdekin, (about 250 yards broad, but a dry course), is intrenched 50 feet. From this point the river flows north for a few miles, then turns north-east, and finally east, to Upstart Bay. About 20 miles upstream a bar of rock, consisting of porphyrite and granite, outcrops in the river bed, and through this bar the river has notched its course. The rocks outcrop in the river bed for about half a mile. The alluvium is here 120 feet above sea-level, and the river trench is 50 feet deep.

The coast to the east of the Houghton River is low, consisting of mangrove swamps. Southward, the North Coast Railway passes over a succession of swampy depressions. The silts in this area are rarely more than 10 feet above sea-level. At Ayr the silts are somewhat higher, being 25 feet above sea-level. Flood distributaries are given off from the Burdekin about 16 miles upstream, and by way of Labatt Lagoon and Sheep Station Creek, flood waters reach Barratta and Hughes Creeks, to the west of Cape Bowling Green. The delta lands enclosed by these distributaries and the Burdekin are completely dissected by other distributaries, of which Kalamia and Plantation Creeks are notable. Towards the river mouth a broad distributary known as the Anabranch isolates Rita Island in time of flood. The shore line south and west of Cape Bowling Green is low and fringed by mangroves, and by wind-drifted dune material, both fixed and mobile. Cape Bowling Green is a narrow spit about 10 miles long which projects between Alva and Hughes Creeks for a distance of 10 miles to the north-west. Towards the north it is somewhat recurved towards the west. It consists solely of alluvium fringed by mangroves, with a considerable amount of dune material. Its presence appears to be due largely to the distribution of material by long-shore currents in the area.

The coastal area between Cape Upstart and Cape Cleveland was

explored by J. Beete Jukes. His description and conclusions are interesting:—

> " . . . On our way we landed at the head of the bay, between Cape Bowling-green and Cape Cleveland. Cape Bowling-green, and the land round it, is absolutely flat, and but little above the level of the sea. It is apparently comprised of large mangrove swamps and mud flats. It looks very like the delta of a large river, and it is probable that considerable streams come both from the northward and the southward, out of the valleys of the mountain-range that runs along the back of this eastern coast, and pour their united waters over this flat. The Burdekin, and others mentioned by Dr. Leichhardt, are, in all probability, these streams. We landed on the south-east side of Cape Cleveland, the geological constitution and the aspect of which is just like that of Cape Upstart. Cape Cleveland, however, is still more broken and abrupt, and also more woody than Cape Upstart, having fine pines in many of its gullies."




Text-fig. 3.—North-South Profiles, to illustrate the topography.

Captain Wickham of the "Beagle" had charted the Burdekin mouths. Jukes passed for a few miles up Heath Creek, a southern distributary, but was unable to reach the main stream (referred to as Wickham's River) on account of shoal waters.

### The Alluvial Deposits.

These deposits have been described by Jack, who stated:—

> "From Cape Palmerston to the mouth of the Herbert River the eastern coast is fringed by a strip of alluvial flat, varying in breadth up to 30 miles or more. Although apparently level to to the eye, it attains an elevation of nearly 300 feet at the base of the coast range west of Townsville. Whether seen on the spot, or as delineated on the geological map, the first idea of the observer is naturally that this alluvial flat is a raised beach; but, in spite of the presence of beds of clay well fitted to preserve fossils, no remains of marine organisms have ever, as far as I have been able to learn, been discovered in it.

"Numerous bores and wells have proved this flat to be composed of alternating beds of clay sands and gravel, the latter being sometimes cemented or consolidated. The gravel, which is sometimes very coarse, contains well-rounded pebbles or boulders such as probably belonged to river beds. In the neighbourhood of Townsville a bore did not bottom on these drifts at 125 feet; a bore (Twaddle's No. 2) in Portion 100 (Stewart's Creek) had 101 feet of drift; another in the same portion (Twaddle's No. 4) had 109 feet of drift. As the sites of these bores are not more than 30 feet above the sea, the rock-head, or old land surface, must be from 80 feet to 100 feet below the present sea-level. No river could possibly have excavated a channel to this depth while the land stood at its present level. The land, therefore, must have been depressed to or beyond the position at which it now stands with reference to the ocean. Moreover, if, as I believe, the alluvia referred to are those of land valleys (either lakes or rivers), their western walls or rim-rocks must have occupied sites now marked by islands in the Pacific or submerged and carried away by marine erosion."

(For further details of borings see Pub. 196 Q.G.S.)

Mr. C. Hedley, in Vol. 1 of these reports, described and illustrated the topography in the vicinity of Townsville. He concluded that Ross Island has been elevated by tectonic action.

The fact that Ross Island has been elevated was demonstrated by Jack, who stated:—

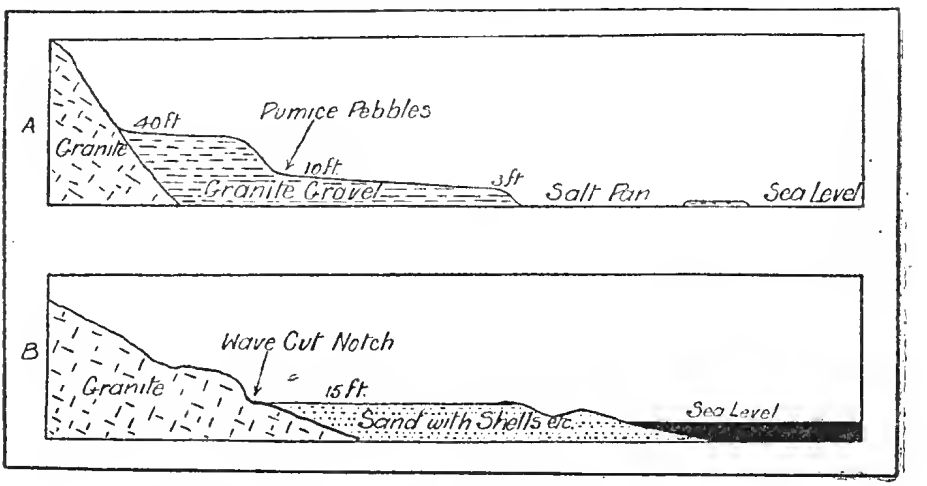
"In Ross Island, Townsville, near the mouth of the Ross River, a thick bed of clay forms part of an estuarine deposit above high-water mark. This is a 'raised beach,' in the ordinary sense of the term. It is crowded with fossil shells, and the late Professor Denton having insisted that it was of Tertiary age, I made a collection, which my colleague examined and found to consist entirely of a species still living in the adjoining seas."

There is fairly abundant evidence of this movement of elevation southward from Townsville.

In the Burdekin delta flats north of Brandon, Mr. Becker, resident there, informed the writer that, in sinking in the flats for water, mangrove roots and sea shells were commonly encountered to a depth of 10 feet to 12 feet. The Cape Cleveland residuals are isolated from the Saddle Mountain residuals by salt pans and salt marshes which extend from the Houghton River on the east, to Crocodile Creek on the west. The salt pans are 2 feet below the general level of the flats. Towards Cape Cleveland these are interrupted by fixed and mobile dunes, which rise to 15 feet above sea-level.

About 1 mile due west of Feltham Cone, in the low mud banks bounding the salt pans, the writer encountered extensive deposits of

oyster shells; other shells were rare. In some cases the shells evidenced calcination and invariably were associated with flakes of various rocks, clearly indicating that the deposits formed part of an aboriginal midden. These shells occurred, not scattered on the surface, but in a loose black and brown clayey soil to a depth of 2 feet, and had been exposed in the low fretted banks bounding the salt pans. The shore line is distant 4 miles from the shell beds, and is cut off by salt pans and mangrove-fringed creeks. The location of the midden is so anomalous that the writer concludes that it is a relic of a former shore line feature when these flats were submerged. The flats fringing the south-western slopes of Cape Cleveland are 20 feet to 25 feet above sea-level, and consist of a loam with abundant disseminated marine shells. On the western shores the flats attain elevations of 10 feet to 20 feet above high-water level, and in places, beach deposits are abundant on the surface. There is no marked faceting of the granite bluffs, which project into the flats, and the writer observed only one small wave-cut notch in a low bluff about 200 yards from the present shore line, fringing which there were abundant marine shells and shell grit in the sand composing the flats. Care was taken to differentiate between midden deposits and raised beach materials. The former were met with both on the south-western and south-eastern slopes of the hills, but the deposits were characterised by an abundance of oyster shells and by the presence of flakes and rock fragments. On the south-eastern slopes of the Cleveland highlands, small "fossil coves" occur whose floors, 5 feet to 6 feet above the adjacent salt pans, are composed of pumice drift and comminuted shell fragments.




Text-fig. 4.—Shore-line Emergence. (A) Profile, northern slopes of Muntalunga Range. (B) South-west slopes of Cape Cleveland Residuals.

The road to the Alligator Creek meatworks follows the northern slopes of the Muntalunga Range. Here may be seen slopes terminating in low bluffs which overlook terraces (Fig. 4), which, in turn, overlook salt pans at sea-level. The lower terrace varies in breadth from 100 to 200 paces, and attains a general elevation of 10 feet above the

level of the salt pans. The vegetation consists of grass and pandanus trees. This terrace is overlooked by a narrower one, on a horizon about 20 feet higher. At the foot of the slope from the upper to the lower terrace, rounded fragments of pumice were found at the grass roots. These mark the strand line. It appears probable that the upper terrace represents material deposited in an alluvial fan by steeply falling streams, and had been notched by the waves, and the material redistributed to form the lower terrace. This was subsequently exposed following a slight lowering of sea-level.

### Conclusion.

The conclusion drawn by the writer is that, in the Townsville area, the present-day features have arisen from a prolonged denudation of a tableland which extended northward and north-eastward from the present tableland scarp, and that the modern features have resulted from the differential erosion effected by streams. A drowning of the coast is apparent here, as elsewhere along the eastern shore-line. The degree of drowning is not known accurately, but, from the evidence of boring, it is known that the old base level of the streams was more than 100 feet below the present base-level. The alluvium fringing the shore-line, probably all that included within the 15-feet contour line, is clearly marine in origin. There is a total absence of evidence which would lead to the conclusion that the remaining alluvium originated under marine conditions. Mr. E. C. Andrews suggested that the altitude of the alluvium at the foot of the tableland indicated a movement of differential elevation. Had this been so, one would anticipate that the streams traversing this material from the tableland to the sea would have effected considerable erosion of the elevated unconsolidated silts. Actually the streams occupy merely shallow, narrow trenches, which, even where the silts are more than 200 feet above sea-level, are rarely of a greater depth than 50 feet.

The alluvial deposits in the Townsville area slope gradually and uniformly from an elevation of between 200 feet and 300 feet at the foot of the tableland scarp, to sea-level. It is probable that, resting on older alluvium, there is a veneer of more recent detritus, gradually thickening towards the tableland scarp. The present profile the writer regards as an equilibrium profile for the steeply falling streams laden with detritus from the tableland (during the periods of heavy rainfall in the catchment areas) across the level plain. It is certain that, after falling from the tableland, the streams are aggrading on the flats, and it is true that deposits seen in the stream trenches are much coarser and heavier towards the base of the tableland. In the lower courses lateral erosion dominates headward erosion, for the streams meander in the low alluvium; their energy is dissipated in transporting material which is deposited in the ever-advancing delta flats.

Fig. 1.—Castle Hill, from the Summit of Mount Louisa.

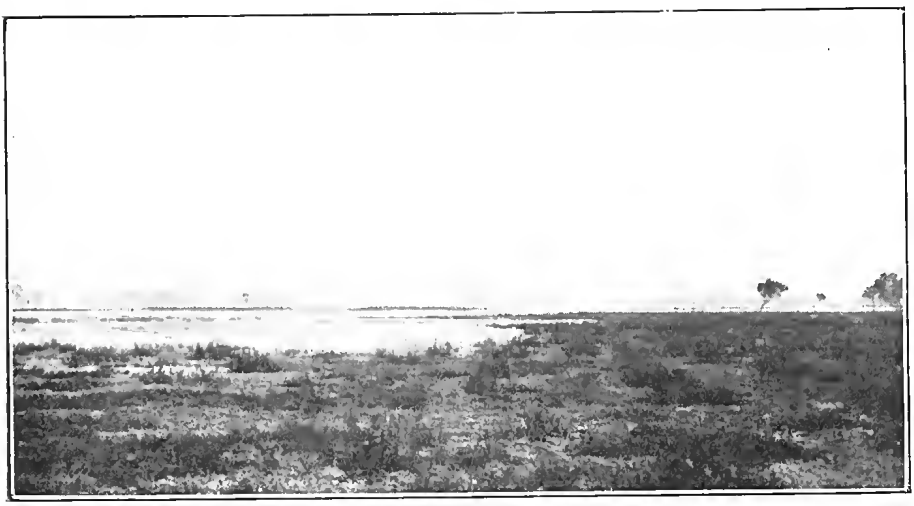
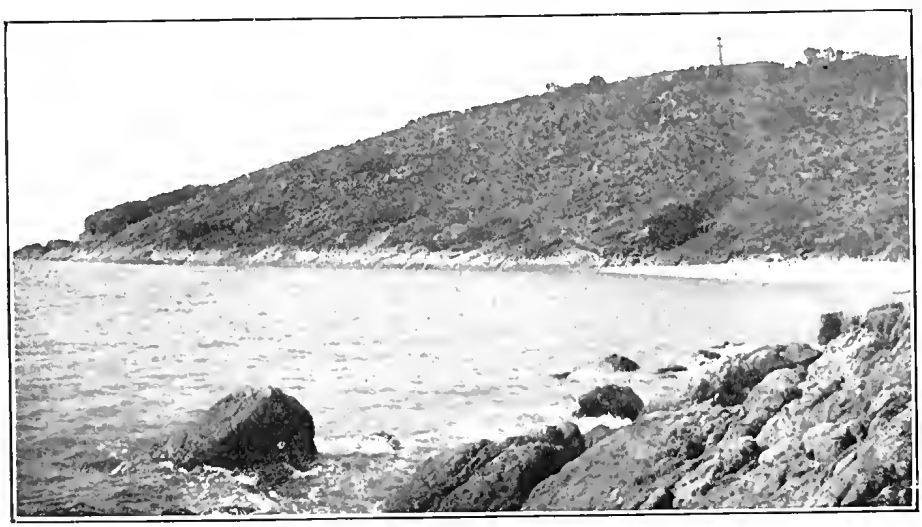


Fig. 2.—The Saddle-Elliot Residuals rise steeply from Alluvial Flats at Sea-level. (View from the North-east.)



*Face page* 87.] Fig. 3.—Cape Cleveland.

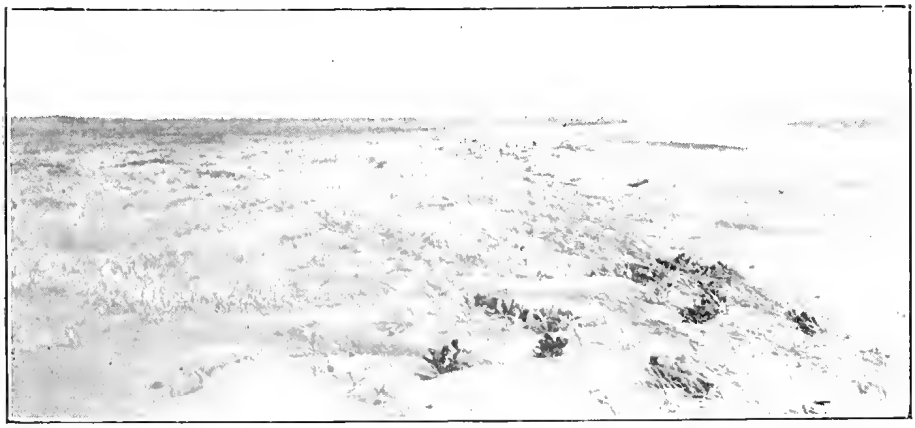


Fig. 1.—The Eastern Shore-line of Cape Bowling Green.

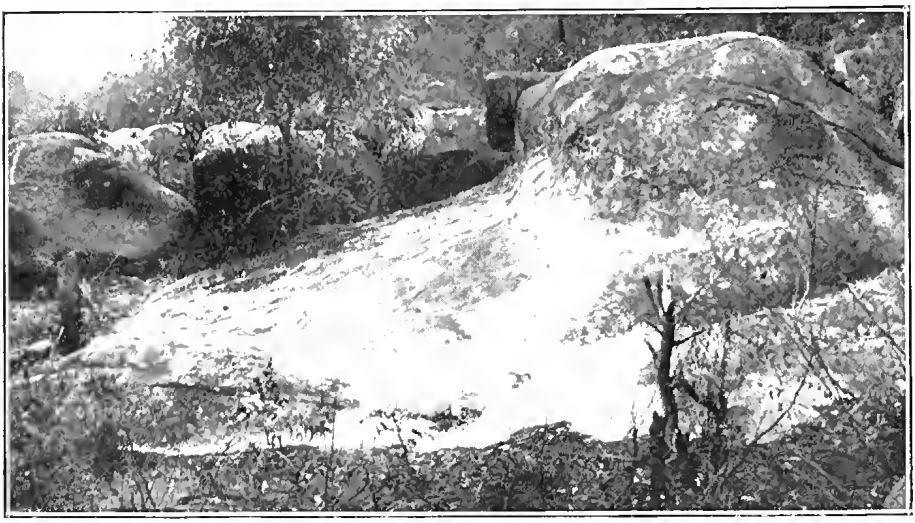


Fig. 2.—Aboriginal Midden in Alluvial Flat, about 1 mile West of Feltham Cone. Probably a Former Shore-line Feature.

Fig. 3.—Wave-cut Notch in Granite, about 20 feet above Sea-level, and 200 yards from present Shore-line, on Western Slopes of Cape Cleveland Peninsula.

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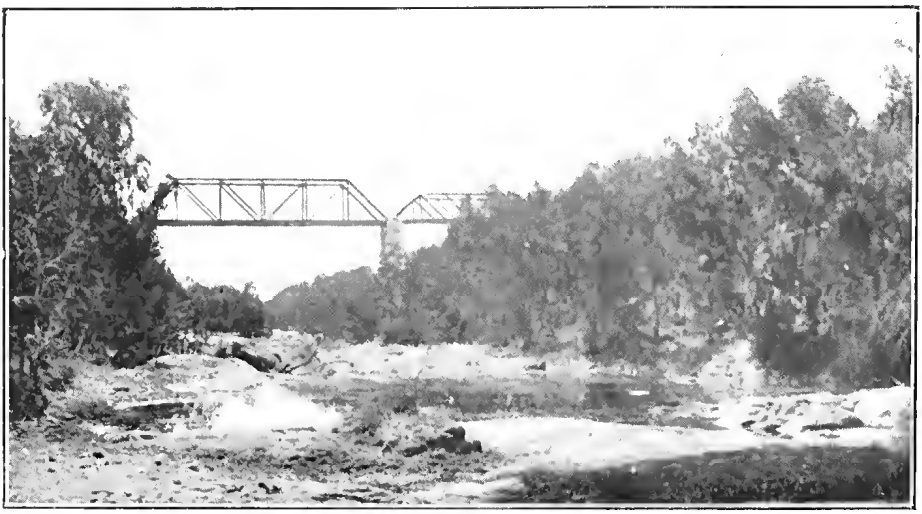

Fig. 1.—Reid River. The Alluvium, which Composes the Banks, is here 250 feet above Sea-level. The Stream Trench is 60 feet deep.

Fig. 2.—The Anabranch, a Flood Distributary which isolates Rita Island (Burdekin River Mouth).

*Face page* 87.]

A movement of slight emergence is apparent along the shore line of this area. Since a similar movement has been demonstrated along thousands of miles of the shore line, the writer prefers to associate this emergence with a slight negative movement of sea-level in recent times.

The writer concludes that the foundation of the coastal plain of this area formerly formed the floor of a broad valley occupied by a stream which flowed meridionally. By foundering and drowning, the seaward run of the valley disappeared and the tributaries from the tableland reached the sea. The modern topography has resulted from erosion and deposition by these streams.

[This investigation was carried out during the author's tenure of a Science Research Scholarship, Sydney University, 1925, in co-operation with The Great Barrier Reef Committee.]

## DESCRIPTION OF PLATES.

PLATE I., FIG. 1.—Castle Hill, from the summit of Mount Louisa.

PLATE I., FIG. 2.—The Saddle-Elliot residuals rise steeply from alluvial flats at sea-level. (View from the north-east.)

PLATE I., FIG. 3.—Cape Cleveland.

PLATE II., FIG. 1.—The eastern shore line of Cape Bowling Green.

PLATE II., FIG. 2.—Aboriginal midden in alluvial flat, about 1 mile west of Feltham Cone. Probably a former shore line feature.

PLATE II., FIG. 3.—Wave-cut notch in granite, about 20 feet above sea-level, and 200 yards from present shore line, on western slopes of Cape Cleveland Peninsula.

PLATE III., FIG. 1.—Reid River. The alluvium, which composes the banks, is here 250 feet above sea-level. The stream trench is 60 feet deep.

PLATE III., FIG. 2.—The Anabranch, a flood distributary which isolates Rita Island (Burdekin River mouth).

# REPORTS OF GREAT BARRIER REEF COMMITTEE

VOL. II., No. 6.

# The Broadsound Drainage in Relation to the Fitzroy River.

By

F. JARDINE, B.Sc.

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No. 6.

# THE BROADSOUND DRAINAGE IN RELATION TO THE FITZROY RIVER.

By F. Jardine, B.Sc.

(Plates IV.-V. and Text-fig. 1.)

## Introductory.

In earlier papers the writer described certain physiographical features of the Lower Fitzroy basin, and of the Port Curtis area, and offered tentative suggestions, pending further investigation, relating the Broadsound and Fitzroy drainage systems.

In this paper a general outline is given of certain features of the Broadsound area, and a more definite statement made of the relationship existing, the author believes, between the Broadsound and Fitzroy drainage systems. The peninsula on the east of Shoalwater Bay is not described.

The writer gratefully acknowledges assistance accorded him by The Great Barrier Reef Committee, by Messrs. F. M. Allan and W. C. Jardine, and by Mr. M. Rogers, of Torilla Station.

## General.

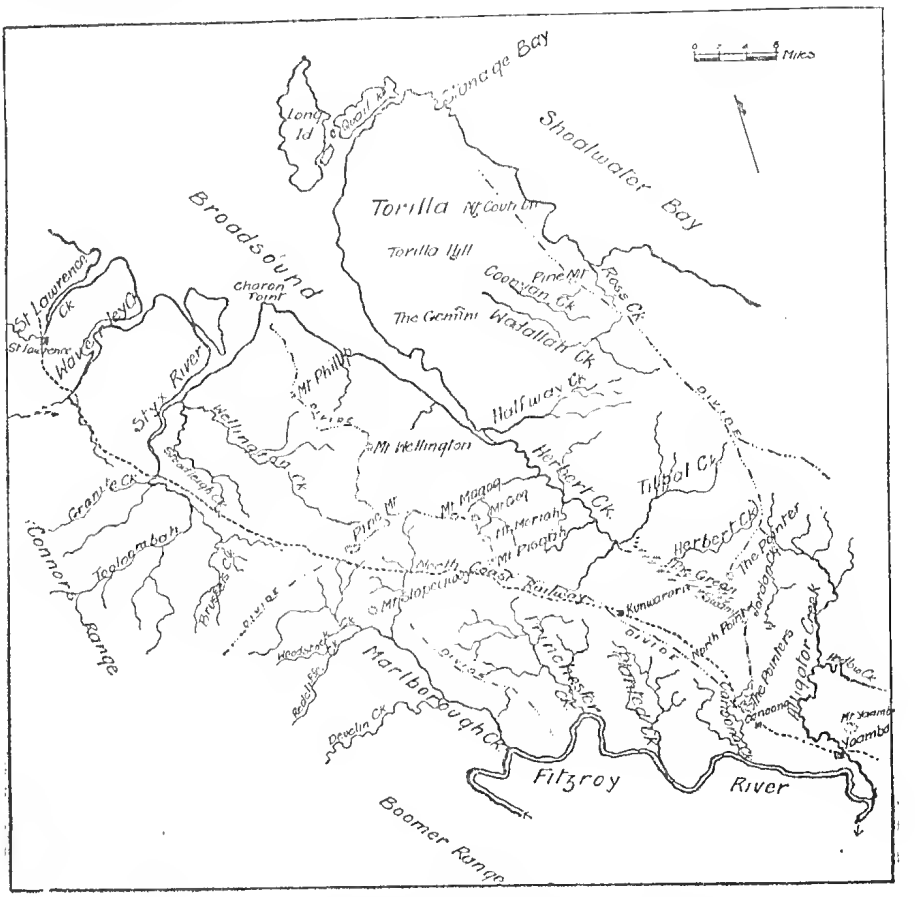
The general north-south trend of the coastline is broken, in the Broadsound area, by a large rectangular bight, extending for about 60 miles. The southern shore of the bight is broken by two broad indentations, which penetrate south-eastward for about 35 miles, that on the east forming Shoalwater Bay, and that on the west, Broadsound. At the heads of these indentations estuarine conditions prevail. Herbert Creek empties its waters into Broadsound, and Head Creek forms the upper waters of Shoalwater Bay.

The peninsula on the east is generally spoken of as "the peninsula," while that separating Shoalwater Bay and Broadsound may be conveniently identified as Torilla Peninsula.

A characteristic of this area is that the residuals and intervening valleys trend in a north-west and south-east direction.

North from Boolburra the south-to-north flowing portion of the Fitzroy River is enclosed on the west by the Boomer Range; northward, as Connor's Range, this escarpment approaches to within 10 miles of the coast line a few miles north of St. Lawrence. St. Lawrence Creek, Waverley Creek, and the Styx River flow from notches in this scarp to Broadsound, traversing in their lower courses extensive "marine plains,"

the elevations of which vary from a few feet to 40 feet above sea-level, and finally enter Broadsound by way of extensive delta lands. These streams are intrenched almost to sea-level in the marine plains. The Styx River basin is separated from that of Herbert Creek by a line of residuals which extends from approximately Charon Point at the mouth of the Styx River, and trends slightly east of south to Pine Mountain, near Marlborough, on the North Coast Railway, rising in Mounts Philip and Wellington to 1,200 feet. The continuity of the range is here broken by




Text-fig. 1.—Sketch Map of the Broadsound Drainage.

two broad notches, which isolate Mount Slopeaway. The southern gap is occupied by Marlborough Creek, and the northern, by Churchill and Pine Mountain Creeks. From here the residuals continue unbroken to the Fitzroy, attaining an elevation of over 1,000 feet, and form the lateral divide between Marlborough and Princhester Creeks, tributaries of the Fitzroy River.

At the point where the Fitzroy changes from a south to north to a west to east flowing stream, in a series of far-flung meanders, it is joined by Marlborough Creek.

The broad basin thus enclosed is drained by the Styx River flowing to Broadsound, and Marlborough Creek flowing to the Fitzroy. The divide between these streams is low and one of great physiographical significance. This feature was described many years ago by Rands, who pointed out that this divide was of the nature of a low tableland, capped by a conglomerate of probably post-Tertiary age.

Northward, this divide overlooks the Wilangi-Waverley "marine plains" which extend to Broadsound, and are drained by the Styx River. South of Marlborough, Marlborough Creek occupies a broad, flat, alluvium-filled valley. Several channels have been excavated in these flats, which are about 250 feet above sea-level. That the modern stream occupies such a broad valley is anomalous.

From a consideration of the foregoing features, the writer concludes that the south-to-north flowing portion of the modern Fitzroy, i.e., from Rookwood Crossing northward, was formerly the upper portion of a stream which flowed by way of Marlborough Creek and the Styx River to Broadsound.

A few miles north-east of Pine Mountain the Philip–Wellington residuals bifurcate, and an eastern group in Mounts Og, Magog, Moriah, and Pisgah, trend away to the south-east to The Pointers, about 4 miles north-west of Canoona. This group forms the main divide between the Broadsound and Fitzroy waters. Marlborough Creek rises in the angle formed by the bifurcation of these residuals, and the inference to be drawn from the modern features is that the breaching of the western line of residuals is a youthful feature. Pine Mountain and Churchill Creeks have isolated Mount Slopeaway from Pine Mountain, and through this gap the North Coast Railway passes to the Wilangi flats.

The eastern group of residuals vary considerably in breadth and altitude, and consist of a series of hills about 1,000 feet high connected by low ridges. The North Coast Railway crosses this divide some 4 or 5 miles west of Kunwarara. Southward, the residuals consist largely of serpentine. A southern deeply-dissected spur from these residuals divides the waters of Princhester and Planted Creeks (tributaries of the Fitzroy), and approaches the Fitzroy at The Gap. South-eastward from The Pointers the continuity of the residuals is broken by a gap 8–9 miles broad, occupied by Alligator Creek, which meanders about in the alluvial flats—here 50 feet to 60 feet above sea-level; this stream joins the Fitzroy near Yaamba. East of Alligator Creek the prolongation of the line of residuals may be traced in the low dissected mesa known as Mount Yaamba, Mount Etna hills, and the low ridges which culminate in the Berserker residuals overlooking Rockhampton.

The Pointers group is isolated from the main line of residuals by a low gap cut by Canoona Creek, and through this gap the North Coast Railway passes from the Yaamba flats to those fringing the divide on the north, finally crossing this divide west of Kunwarara.

From The Pointers group, residuals known as the Pointer Range trend northward, dividing the Alligator Creek waters and those of Herbert Creek, and comprise a series of pinnacles 600 feet–800 feet in altitude connected by low ridges. A notable break occurs between North Pointer and The Pointer, two of the northern pinnacles in the Pointer Range. Here a gap about 3 miles broad occurs. The surface is quite plane, and through this air gap the flats in which Herbert Creek rises join the Alligator Creek flats. Northward from this point the residuals are known as the Normanby Range, and at Pine Mountain (the second of the name in the area) reach the coast on the western shore of Shoalwater Bay and continue along the eastern shore of Torilla Peninsula to Stanage Bay, to the north-west.

The air gap between The Pointer and North Pointer is partly occupied on the west by an extensive swamp known as the Green Swamp, which extends for 6–8 miles to the north-west. This is the source of Herbert Creek proper, which continues the swamp alignment to the north-west. The swamp is merely a broad depression, receiving Upper Herbert and Tilpal Creeks from the north-east, and Banyan Creek from the south-west.

Jordan Creek, flowing from the north, drains into a swampy depression about 2 miles east of the gap. Alligator Creek is distant an additional 4 miles to the east.

Thus, from the presence of the air gap in the Pointer Range, the location of extensive swamps on the divide (here a plane surface) between the Herbert and Alligator Creeks, and from the general evidence which the writer outlined in previous papers, the conclusion is drawn that the course of the Lower Fitzroy, before reversal, was by way of Lower Alligator Creek, the Pointer Gap, and Herbert Creek to Broadsound; to this stream Hedlow Creek was a normal tributary.

The extensive "marine plains" of the Broadsound area are interesting features. The flats slope gradually from sea-level, attaining altitude of over 100 feet at the bases of the enclosing hills; the major portions are, however, below 40 feet above sea-level, and it is clear that a considerable area has been exposed by the recent lowering of sea-level. The Herbert Creek estuary is fringed on either side by extensive flats. Structurally, Torilla Peninsula comprises a roughly triangular area of marine plains on the west, narrowing northward, limited on the east and north by residuals which fringe the shore line. Rising through the plains, numerous low faceted monadnocks relieve an otherwise plane surface.

Evidence of the retreat of sea-level was observed at the mouth of Ross Creek (flowing to Shoalwater Bay near Pine Mountain). On the northern banks of the creek, low faceted bluffs of muscovite schists occur, the bases of which are 10 feet above sea-level, some little distance from the present shore line.

About 1 mile south of Stanage Bay, Mr. M. Rogers pointed out to the writer decisive evidence of the lowering of sea-level. Here the bay-head flats (10 feet above sea-level and 500 yards broad) are cut off from the shore line by sand dunes 40 feet high. At the foot of the bluff overlooking the flats on the west a calcareous beach rock composed of sand, coral fragments, shells, and quartz pebbles occurs, overgrown by grass. Outcrops of this rock occur on various parts of the flats as one approaches the shore line.

The writer subsequently visited the Torilla marine plains under the guidance of Mr. J. Allan towards the close of 1926; as this period corresponded to an unusually dry period in the district, the plains, usually clothed in lush herbage and dotted with extensive swamps inhabited by innumerable native wildfowl, were parched. Scattered over the surface the writer found numerous recent marine shells.

Thus the evidence clearly demonstrates a retreat of sea-level of about 15 or 20 feet.

[This investigation was undertaken during the author's tenure of a Science Research Scholarship, Sydney University, 1925, while co-operating with The Great Barrier Reef Committee.]

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[The author takes this opportunity of acknowledging and correcting an error appearing on page 107 of a previous paper, "The Physiography of the Port Curtis District." Discussing Professor Taylor's theory relative to evolutions of the streams of the district, it is stated that Professor Taylor considered that the Boyne River formerly formed part of the headwater drainage of the Condamine. This should be deleted. Professor Taylor referred to the Boyne, a tributary of the Burnett River, and not to the Boyne River of the Port Curtis district. The writer apologises for misrepresenting Professor Taylor's theory regarding this particular river. This error was pointed out by Dr. E. O. Marks in a communication, subsequently withdrawn, to The Great Barrier Reef Committee.]

## DESCRIPTION OF PLATES.

PLATE IV., FIG. 1.—The Green Swamp, located on the divide between Herbert Creek and Alligator Creek.

PLATE IV., FIG. 2.—The gap at Marlborough, through which the North Coast Railway passes to the Wilangi flats.

PLATE IV., FIG. 3.—Flats drained by Upper Herbert and Tilpal Creeks. View from summit of hills overlooking Merinal (North Coast Railway) looking northward.

PLATE V., FIG. 1.—Evidence of shore-line emergence. Beach rock about 1 mile south of Stanage Bay (*see* text).

PLATE V., FIG. 2.—The faceted western slopes of Torilla Hill, a monadnock rising through the Torilla Marine plains. Recent marine shells occur here on the plains.

Fig. 1.—The Green Swamp, located on the Divide between Herbert Creek and Alligator Creek.

Fig. 2.—The Gap at Marlborough, through which the North Coast Railway passes to the Wilangi Flats.

Fig. 3.—Flats drained by Upper Herbert and Tilpal Creeks. View from Summit of Hills overlooking Merimal (North Coast Railway) looking Northward.

*Face page* 92.]

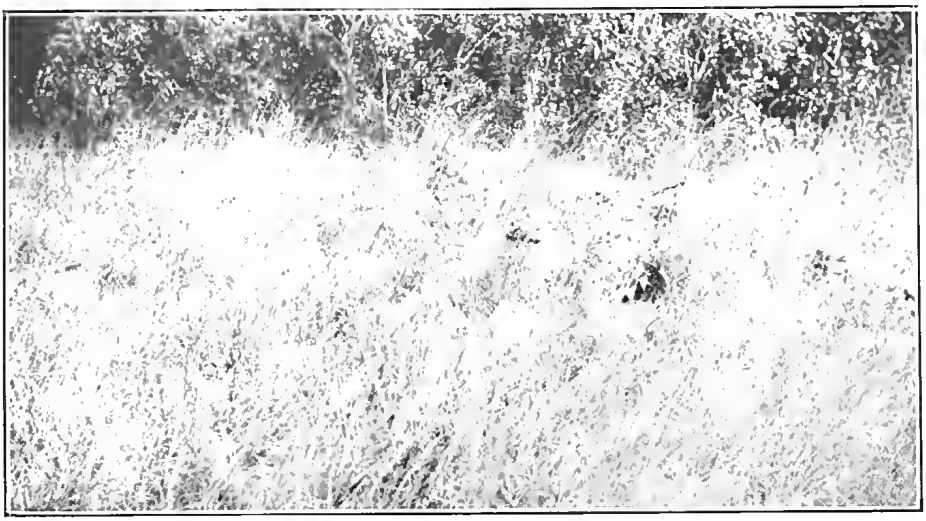

Fig. 1.—Evidence of Shore-line Emergence. Beach Rock about 1 mile South of Stanage Bay (*see* Text).

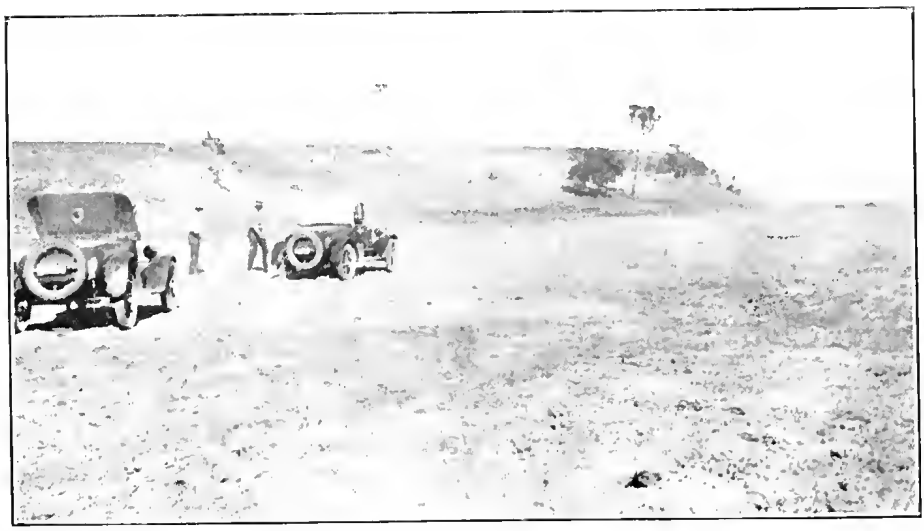

Fig. 2.—The Faceted Western Slopes of Torilla Hill, a Monadnock rising through the Torilla Marine Plains. Recent Marine Shells occur here on the Plains.

*Face page* 92.]

# REPORTS OF GREAT BARRIER REEF COMMITTEE

VOL. II., No. 7.

# Bramble Cay, Torres Strait.—Geological Notes

By

F. JARDINE, B.Sc.

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No. 7.

## BRAMBLE CAY, TORRES STRAIT.—GEOLOGICAL NOTES.

F. Jardine, B.Sc.

Plates VI.-VII. and Text-figures 1-3.

The nucleus of igneous rocks, which projects through the centre of the reef upon which Bramble Cay is situated, was briefly described by Jukes.[1]

> " . . . Thirty miles north of Erroob, another patch of igneous rock shows itself in the centre of a small reef, called by us Bramble Key, but the native name of which is Caedha. This is a mass of rock twenty or thirty feet high, and about twenty yards across in the centre of a coral reef, which has a sand key on one end of it. Another small patch of the same rock is seen three-quarters of a mile distant, to the S.E., dry only at low water. The rock has a singular appearance, being a dark red cellular lava, the cells of which are filled by a white earthy mineral in a pulverulent state."

Bramble Cay was not visited by Haddon during his stay in Torres Strait, and in a paper, "The Geology of Torres Straits," by Haddon, Sollas, and Cole,[2] Jukes's descriptions of the reef are quoted. A specimen of the volcanic rock collected by Jukes was examined by these authors and pronounced to be a vesicular basaltic andesite.

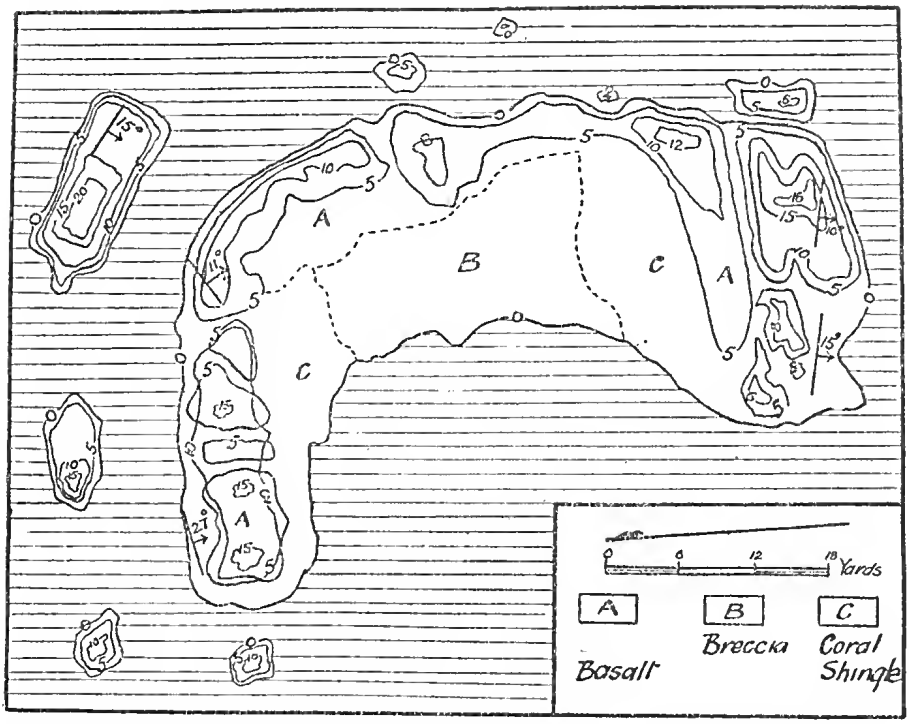
The outcrop is in the form of a small crescent convex to the east; the rocks extend for 70 yards in a north-south direction and for 50 yards in an east-west direction. Isolated blocks form the trace of a second crescent parallel to the main outcrop on the northern side, distant but a few yards. (*See* Text-fig. 1.) A few hundred yards north of the central outcrop, two small rock pinnacles rise 6 or 8 feet above the level of low water. The crescentic outcrop rises on the northern part 15-20 feet above the level of low water; during the period of high water the rocks become covered except for a few spray-swept pinnacles. (The springs here rise 12 feet.)

The rocks constituting the various outcrops in the atoll are entirely volcanic, and comprise basic lava flows and breccia. The strikes of the former vary between N. 30° W. and W. 10° N., and dips from 10° to 27° southwards. The field occurrence and relationship are indicated in

[1] J. Beete Jukes.—"Narrative of the Surveying Voyage of H.M.S. 'Fly.'" London, 1847.

[2] Professors Haddon, Sollas, and Cole.—"On the Geology of Torres Strait"; Transactions of the Royal Irish Academy, Vol. XXV., Part XI., 1894.

the form line sketch (Text-fig. 1). The isolated outcrops north of the larger group of rocks consist entirely of breccia. The latter apparently offers less resistance to marine erosion than the flows, for the elevated crescent is composed almost entirely of basalt, while the breccia outcrops at low-water level on the concave side as indicated. From this central breccia mass radiating dykes traverse the flows towards the north, and these have been eroded by the waves, forming caves and arches in the




Text-fig. 1.—Form-line Sketch of Outcrop of Igneous Rocks, Bramble Cay. (Datum level is low-water level.)

northern horn of the crescent. While it is clear that the rocks of Bramble Cay mark a focus of eruption, and this, from the evidence offered in the Murray Islands and Darnley Island, was of recent geological age, the rock outcrops here are so small and fragmentary that it is impossible to interpret a cone form.

Lithologically, the rocks constituting the outcrop exhibit varying characters. The flows vary from a dark-grey, aphanitic, compact rock, to one of a dark chocolate-brown colour towards the top, where alternate compact and cellular bands occur. The porosity varies considerably; slaggy, scoriaceous, and pumiceous varieties occur. Fluxion structure is well exhibited in the elongation of the steam vesicles and in the occurrences of lenticular or banded structures observed in the dark-grey compact lava. In places a distinct bounding plane occurs, separating the overlying chocolate-coloured lava and the underlying more compact rock, but often there is an imperceptible transition. Bands and lenticles of the former occur occasionally in the latter rock.

Dykes of breccia dipping vertically, often no more than a few inches wide, traverse the lavas. The breccia has apparently been intruded along fissures*; since this material is readily eroded, these are marked by narrow clefts.

The overlying rocks are markedly amygdaloidal, but this is not generally applicable to the scoriaceous varieties. This secondary infilling occurs in cracks and irregular cavities in the upper zone, as well as, as amygdules.

Microscopically the rocks, while they range in texture, show little variation in mineralogical composition. They are basic lavas—olivine basalts or the equivalents—in which the proportion of phenocrysts to groundmass is somewhat inconstant.

In the dark-grey compact rock the phenocrysts of felspars determined range from labradorite to bytownite, while those of the second generation in the groundmass are labradorite. A pale non-pleochroic variety of augite is present as idiomorphic to sub-idiomorphic phenocrysts, occasionally twinned, as well as less abundant granules in the groundmass. Sub-idiomorphic olivine crystals of intratelluric origin occur abundantly. Both olivine and augite are comparatively fresh. Magnetite occurs abundantly, both granular and idiomorphic. The groundmass of the rock is holocrystalline, being composed of minute laths of felspar, with not abundant augite of granulitic habit, and iron ore. Flow structure is exhibited in the orientation of the felspar laths of the groundmass, in parts.

The banded rock described exhibits similar mineralogical features. Flow structure is apparent both in the orientation of the felspar-microlites of the groundmass, which is hypocrystalline, and in the elongation of the vesicles. The felspar phenocrysts are occasionally zoned. The olivines, which are largely idiomorphic, are altered peripherally to reddish-brown lamellar iddingsite.

The chocolate-brown, vesicular lava, which towards the upper surface is amygdaloidal, is hypohyaline. In parts the rock is pumiceous. Distributed sparsely through a brown glass, large subidiomorphic crystals of augite occur, which are chloritic on their peripheries. These contain abundant minute dark inclusions (undetermined), and magnetite granules. Olivine aggregates are absent, and felspar phenocrysts rare.

The amygdules vary considerably in size, and are composed of an extremely fine-grained earthy material of low double refraction, which proved to be an earthy hydrous phosphate of alumina. This mineral, which occurs both as amygdules and as an infilling in irregular cavities, is white, in parts greenish-white, hardness 2–3, having a sub-conchoidal to smooth fracture. It is sometimes traversed by narrow veins of a pale-

* *Vide* "The Natural History of Igneous Rocks," Alfred Harker, London, page 52.

green crystalline mineral which presents a drusy appearance on the fractured surface, of hardness 4–5. These veins are rare, but were occasionally observed attaining a width of ¼ to ½ inch in the larger masses of the earthy variety filling irregular cavities in the rock. This mineral also proved to be a hydrous phosphate of alumina. In the earthy variety traces of siliceous and iron impurities were detected. The phosphate of alumina is clearly of secondary origin, and has resulted from the interaction of the solutions which leach the sea-fowl excretions deposited on the upper rock surface, upon a decomposition product of the lava.

Printer's error. Should read:- line No. 11 " " 14 " " 13 " " 12 " " 15

It has been suggested that aluminium hydroxides may result from desilication of clay is sometimes effected by the action of sulphuric acid process is not clearly understood. Certain investigators conclude that the decomposition of basic lavas, effected by alkaline solutions. The and sodium salts; in Arkansas[3] about 10 feet of bauxite overlies a nepheline syenite, and it has been suggested that the syenite has been subjected to the action of salt or alkaline water and some of the dissolved aluminium oxide precipitated in the colloidal form.

It appears probable that at Bramble Cay a similar reaction between the sea water and the basic lava has been operative, resulting in the infilling of vesicles and fissures by deposition of colloidal aluminium oxide; that this in turn has been subjected to the action of ammonium phosphate arising from the decomposition of the sea-fowl excretions on the upper rock surface, and the percolation of leaching solutions, in a similar manner to that demonstrated by M. A. Gautier[4] on the floors of the Grotte de Minerve, where such solutions have reacted with the clay of the floors of the caverns producing hydrous phosphates of aluminium.

Teall has demonstrated that the trachytes of the Clipperton Atoll in the North Pacific have had, as a result of the leaching down from the overlying guano of solutions of ammonium phosphate, the original silica of the rocks replaced, and these converted to phosphatic rocks.[4]

The breccia composing the two smaller outcrops north of the central rocks in the atoll is composed of coarse angular fragments, up to 6–7 inches in diameter, of dark compact lava exhibiting small white laths of felspar, chocolate-brown pumiceous fragments, dark-grey and brown vesicular lavas also exhibiting white felspar laths, and amygdaloidal varieties. The matrix is a pumiceous to compact variety of the uppermost flow of the main outcrop. The mineralogical composition of the fragments and cementing matrix is similar to that of the rocks previously described.

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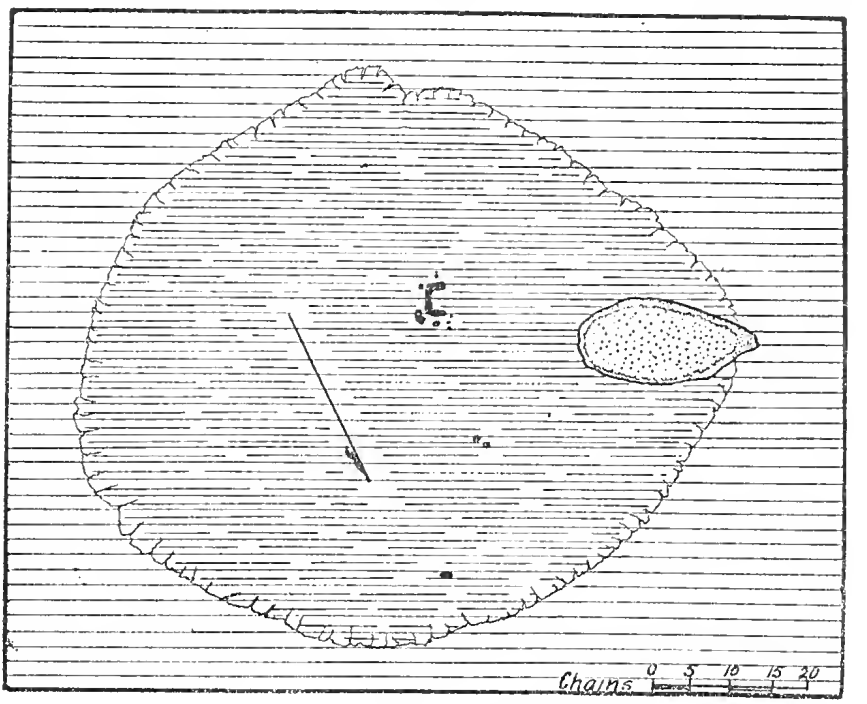
[3] A. T. Moses and C. L. Parsons.—"Elements of Mineralogy, Crystallography, and Blowpipe Analysis." New York, 1916.

[4] G. P. Merrill.—"The Non-Metallic Minerals." New York, 1904.

### The Black Rocks.

About 5 miles south-west of Bramble Cay a small group of rocks rises 8–10 feet above the level of low water. In extent the outcrop is comparable with that at Bramble Cay. It comprises six rectangular and a few smaller blocks arranged in a linear manner about an east-west axis. The rocks rise through a reef much smaller in extent than that fringing the Bramble Cay nucleus; the Black Rocks are disposed eccentrically to the south in the encircling coral reef.

The rocks are composed of coarse ash or tuffaceous beds, with a well-developed banded structure of coarse- and fine-grained materials in bands 1–2 inches broad, which give rise to a regular stratification. Certain broader bands of a uniformly fine-grained material occur, without included fragments. The beds strike E. 20° S. and dip south-westward




Text-fig. 2.—Bramble Cay and Reef.

at 15°. The rocks are strongly jointed in a direction N. 10° E., and these vertical joint planes are intersected by a second system of joint planes at right angles. The former present planes of weakness, and the partition of the outcrop is due to this jointing. The northern edges of the blocks are highest and the slope to the south-west conforms to the dip of the beds. On the northern sides small benches are developed.

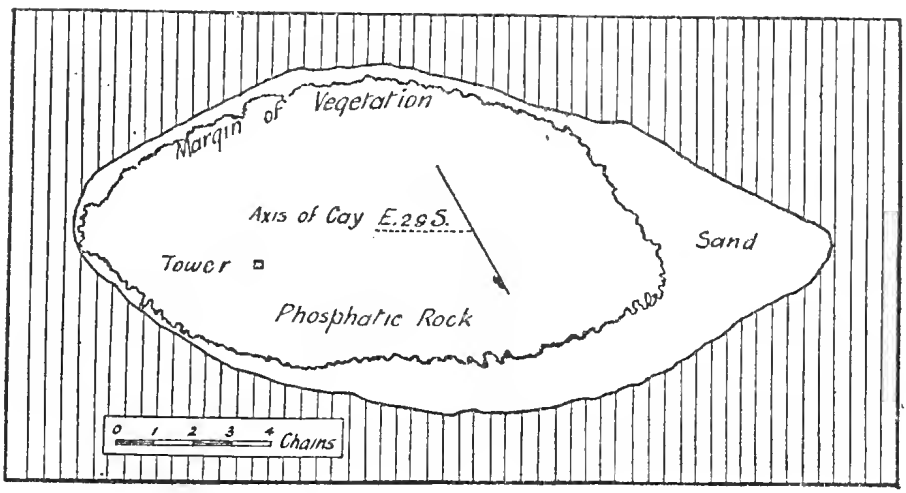
These rocks are almost continuously submerged, and are very much decomposed. Fragments of dark-grey and reddish lavas occur in an

earthy matrix. A microscopic examination of the included lava fragments demonstrates these to be olivine basalts considerably decomposed. The groundmass is occasionally glassy. In the cementing matrix fragments of olivine and augite crystals occur in a fine-grained material which is somewhat calcareous.

These rocks are similar in character to the ash beds of the Murray Islands and Darnley Island. The outcrop, it may be concluded, marks the site of an eruption, a fragment only of the ash cone remaining.

### The Sand Cay.

The Bramble Cay reef is more or less circular in outline. The greatest diameter is 1 mile. (See Text-fig. 2.) On the leeward reef-margin a small sand cay occurs, elevated, but a few feet above the level of high-water springs. The cay, which is about 20 chains long and 8 chains broad, is stream-lined about an axis running from E. 30° S. to W. 30° N.—which closely approximates to the direction of the prevailing




Text-fig. 3.—Sketch of Bramble Cay.

trade winds. (See Text-fig. 3.) The cay is composed almost entirely of foraminiferal tests with few disseminated shells and coral fragments. A marked feature is the absence of comminuted material. The location and outline of the cay clearly demonstrates the controlling influences of both wave and wind action. Though at Bramble Cay there is an absence of any considerable débris accumulation on the windward side of the atoll, this is not invariably the rule. On Pipon and Hannibal atolls the author has observed the occurrences of small cays on the windward reef-margins, in addition to those located on the leeward margins. The former are invariably composed of coarse heavy fragments of coral with shells (coral shingle), while the latter comprise

pulverous materials arising from the mutual trituration of coral and shell fragments. The sorting and accumulation of the coarser and finer materials on the windward and leeward margins, respectively, are simply functions of wave transportation. In many cases the débris accumulations on the windward margin occur in the form of a narrow crescentic rise, the convexity of which is directed to windward. Such a feature is apparent at Bramble Cay, where, on the windward side of the reef a low crescentic bank 1–2 feet above the level of low-water springs occurs, composed of wave-swept coral fragments.

The sand cay on the leeward side of the atoll marks the focus where the transporting power of the waves is reduced to a minimum. A form of equilibrium is established, and with seasonal changes in the wind direction (and therefore wave attack) new forms arise; thus there is a constant readjustment in shape consequent to the prevailing conditions.

The problem of the consolidation of beach materials into beach rock is one to which investigators have directed considerable attention; explanations regarding particular occurrences are often satisfactory, but the problem is one which does not admit of generalisation.

The author has observed the occurrences of beach rock fringing cays on various atolls, notably Pipon and Coconut Island. At Bramble Cay no beach rock was observed, although the reef is isolated and freely exposed to wave action, and the material composing the cay is wholly calcareous. The central portion of the cay has, however, a thin capping of consolidated material. This capping varies between 12 and 18 inches in thickness, and is hardest at the surface, becoming friable below the outer crust. Below the consolidated capping, for about 10 inches, the foraminiferal sand is loosely consolidated, while below this depth the sand is unaltered, being mobile and fresh in appearance. The surface material has a leached appearance, the tests being often skeletal and bleached.

The cay is vegetated by a low, dense herbage and is the breeding ground for innumerable sea-fowl; the presence of abundant decaying organic matter and phosphatic material are the important factors inducing consolidation.

The rock is phosphatic, but of low grade. Formerly the cay was occasionally visited by boats, and guano collected, but the material proved to be of little economic importance.

The consolidation of the materials is due to various reactions. The production of calcium phosphate by the interaction of ammonium phosphate solutions leached from the overlying accumulation of bird fæces, upon the underlying calcareous materials, is obvious. In addition to this reaction the deposition of secondary lime carbonate functions in

effecting consolidation, just as this process is one which induces lithification of beach materials. Solution of lime carbonate may be effected by aerated rain water, and in the presence of decaying organic matter the dissolved lime may be reprecipitated as a cementing material. Again, during the monsoonal period, the rain water percolates to a depth, in its passage becoming saturated with lime carbonate. Subsequently the surface of the ground becomes warmed by the sun's rays, and, through capillarity and evaporation, the lime is redeposited towards the surface.

It is probable that here, cementation by deposition of lime is subordinate to that effected by calcium phosphate, for the rock is friable and porous, the degree of consolidation not being advanced.

[This investigation was carried out during the author's tenure of a Science Research, the Deas Thomson (Mineralogy) and the John Coutts Scholarships, Sydney University, 1924, and in co-operation with the Great Barrier Reef Committee.]

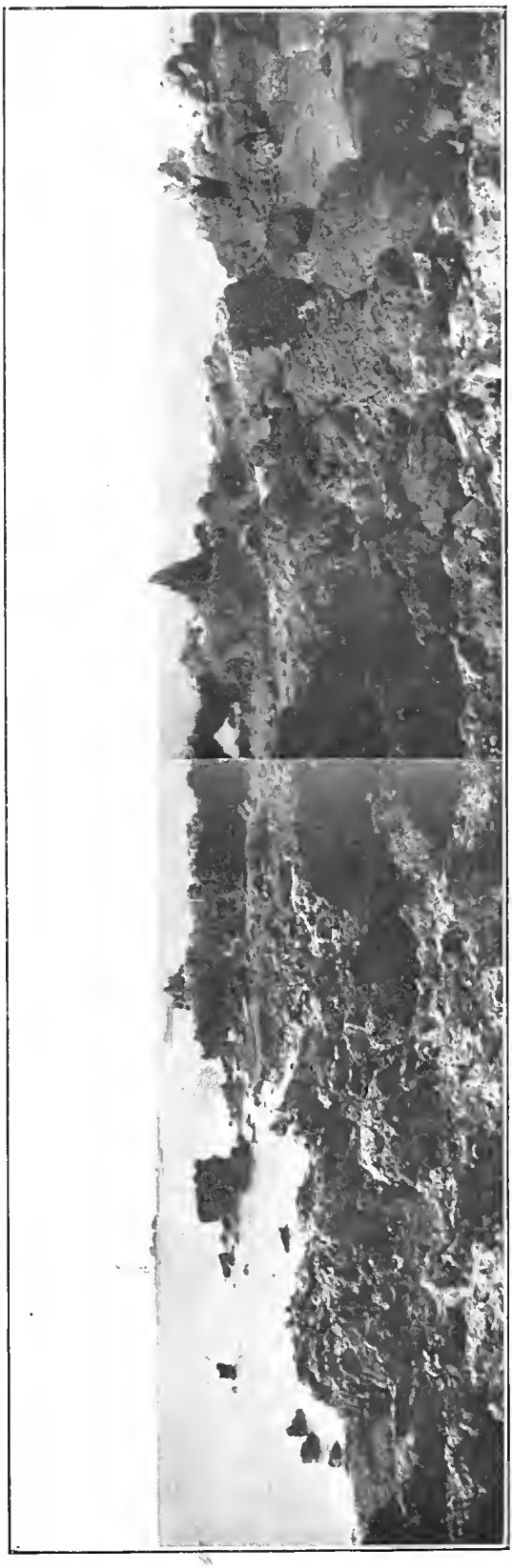
## DESCRIPTION OF PLATES.

PLATE VI.—Bramble Cay.

PLATE VII., FIG. 1.—Consolidated sand capping Bramble Cay in parts. The bird is a Noddy (*Anous stolidus.*)

PLATE VII., FIG. 2.—The cay is inhabited by innumerable sea-fowl.

PLATE VII., FIG. 3.—The low, dense herbage of Bramble Cay. In the foreground are two Silver Gulls (*Bruchigavia novæhollandiæ.*)



Bramble Cay.

*Face page* 100.]

Fig. 1.—Consolidated Sand capping Bramble Cay in Parts. The Bird is a Noddy (*Anous stolidus*).

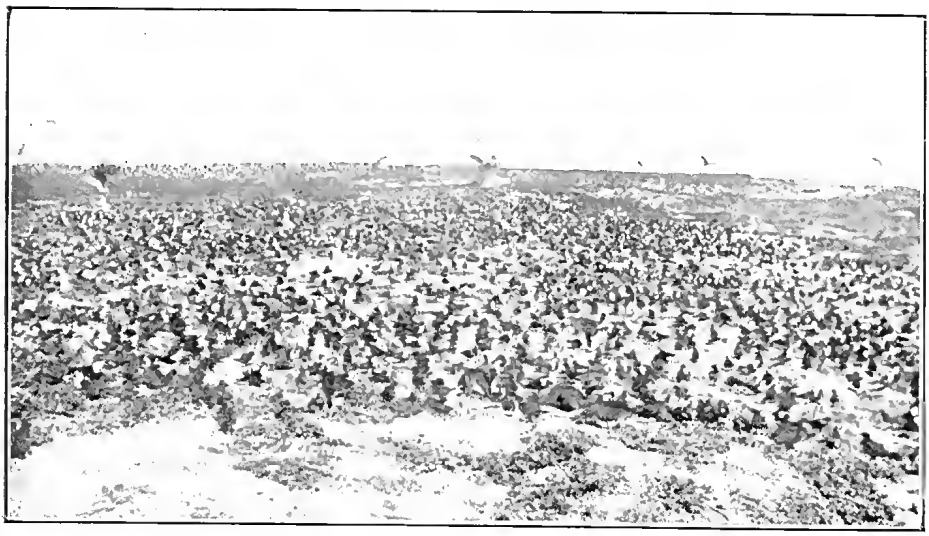


Fig. 2.—The Cay is inhabited by Innumerable Sea-fowl.

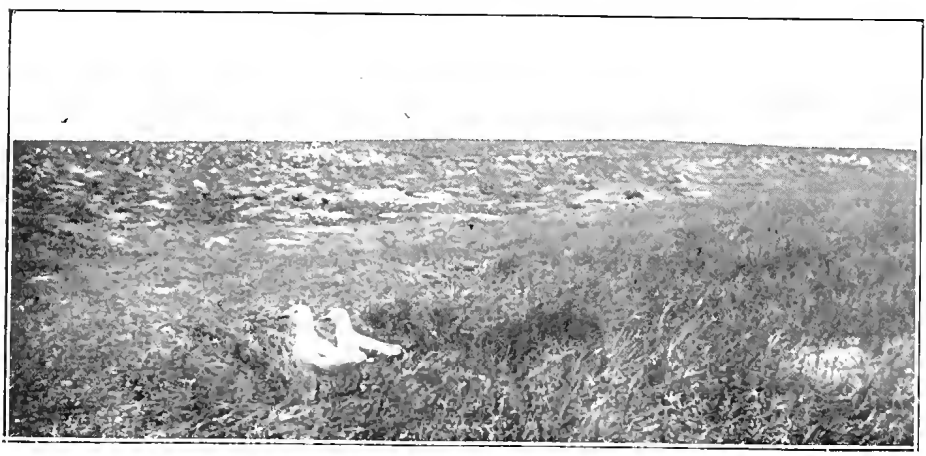


Fig. 3.—The low, dense Herbage of Bramble Cay. In the Foreground are two Silver Gulls (*Bruchigavia novæhollandiæ*).

*Face page* 100.]

# REPORTS OF GREAT BARRIER REEF COMMITTEE

VOL. II., No. 8.

# Darnley Island—Geological and Topographical Notes

By

F. JARDINE, B.Sc.

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Great Barrier Reef
Marine Park Authority
P.O. Box 1379
Townsville 4810

No. 8.

# DARNLEY ISLAND—GEOLOGICAL AND TOPOGRAPHICAL NOTES.

By F. Jardine, B.Sc., Science Research Scholar, Deas Thomson (Mineralogy) Scholar, John Coutts Scholar (1924), University of Sydney (co-operating with the Great Barrier Reef Committee).

(Plates VIII.–IX. and Text-figures 1–3.)

## Introductory.

Erub, or Darnley Island, as it was named by Bligh in 1792, is the largest of the easterly volcanic group of Torres Strait islands. Formerly the island supported a dense population. It was here, in 1793, that a boat's crew from the "Hormanzeer" (Capt. W. Brampton, Commander), bound from Norfolk Island to Bombay, was sent ashore. Five out of a crew of seven were killed by the natives. The "Hormanzeer" was accompanied by the "Chesterfield" (Capt. M. B. Alt, Commander). Brampton and Alt landed 44 men, and in reprisal burned 135 huts, 16 large canoes, and destroyed many gardens on the island.

## Previous Literature, &c.

An accurate and comprehensive general account of this island has been given by Jukes,[1] whose notes were supplemented by those of Macgillivray, who revisited the island as scientist aboard the "Rattlesnake."

Haddon's first visit to the island was of brief duration; the highest point was ascended and a specimen of olivine basalt collected. In the paper, "The Geology of Torres Strait,"[2] Jukes's descriptions were largely quoted. During subsequent visits Haddon largely confirmed Jukes's observations.

The writer, through the generosity of the Great Barrier Reef Committee and the courtesy of Mr. I. M. Cowlishaw, B.E., Engineer for Lighthouses, Queensland, was enabled to accompany the Scientific Director on a brief visit to the island. These notes serve merely to supplement the observations of earlier writers.

## General.

From the north, the striking feature of Darnley Island is a dome-shaped hill which slopes regularly to east and west. The north-east

[1] J. Beete Jukes.—Narrative of the Surveying Voyage of H.M.S. "Fly," London, 1847.

[2] On the Geology of Torres Strait, by Professors A. C. Haddon, W. J. Sollas, and G. A. J. Cole. Transactions of the Royal Irish Academy, Vol. XXX., Part XI., 1894.

headland of the island has a juvenile profile. The cliff overlooks a broad rock flat at sea-level. On closer approach, the soft contour of the island is scarred by a series of cliff sections 100 feet–200 feet high, centrally situated, which taper to sea-level on either side. The dome-shaped peak, Lalor, rises to 610 feet in the western half of the island. From this peak, the slope to the southern shore line is unbroken and gentle, save for a steep declivity towards the summit and a dry stream course which bisects the southern slopes and enters a shallow mangrove-fringed bay towards the south-east of the island. The long slope is continuous also towards the west, culminating in a narrow peninsula bound by low bluffs, which is isolated by a small col. The northern slopes are more rugged. A stream course rising in Lalor and draining into Treacherous Bay has trenched the island. Arising from this stream erosion, Lalor has the appearance of being fringed by the fragment of a cusp on the north and north-west. On the northern side of the island the long slopes are absent—these have been truncated. The marine-cut cliffs are 100 feet or more in height.

Save for an outcrop of volcanic ash beds in the cliffs of Treacherous Bay, the island is composed entirely of lava, the disintegration of which has produced a soil of great fertility.

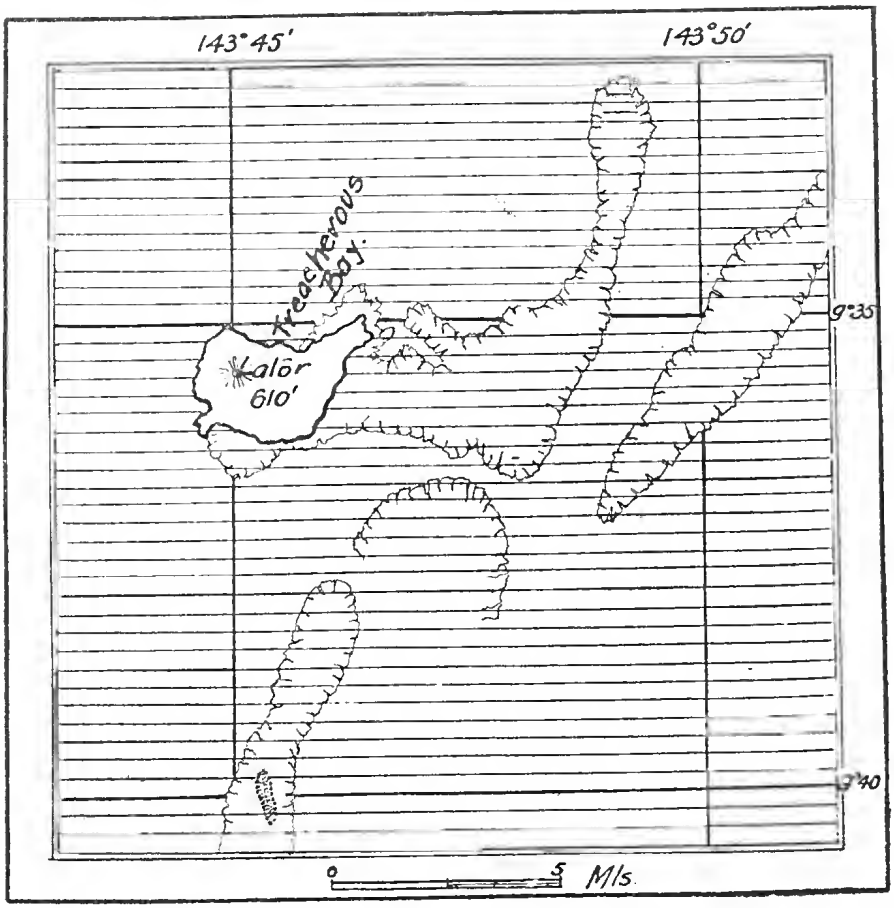
## Geological Notes.

### (a) *The Ash Beds.*

The visible outcrop of the ash beds in the cliffs of the northern shore line is 100 feet–200 feet in thickness. The basal beds outcrop below sea-level. The beds are intersected by two vertical systems of joint planes which strike N. 30° W. and W. 10° N., respectively. Due to the presence of this jointing, the cliff faces in places are fractured in an angular or roughly columnar manner. (Plate VIII., fig. 1.) On the eastern and western flanks of the outcrop, the beds gradually subside and occur in the cliff sections overlain by basalt; finally they pass below sea-level. On the eastern margin the beds dip S. 30° E. at 30°, while towards the western boundary the dip is S. 27° W. at 12°. The pseudo-arched structure observed in the cliff section arises from the fact that the beds dip centrifugally from a centre located in the sea some little distance to the north of the island. It is clear that the ash beds of the island constitute portion of an ash cone, the cliff exposure being a vertical section cut in an east-west direction approximately, across the southern cone slope. The location of the crater is roughly indicated by prolonging the directions of dip of the beds to their point of intersection. (Text-fig. 2.)

The ash beds have a curious banded appearance, arising from the presence of dark red-brown to light-yellow strata. There is no well-marked cleavage associated with the colour banding. The bands vary in

thickness from 2 feet to ½ inch. The rock is fine-grained and somewhat loosely consolidated. In the basal exposed sections numerous basalt inclusions, varying in size from blocks 2 feet in diameter to pellets, occur. Associated with these, large rounded blocks of a compact yellowish limestone occur. In thin sections of this material irregular markings




Text-fig. 1.—Darnley Island and Coral Reefs.

and outlines were detected, apparently the traces of organic remains. The rock is fine-grained, but in the markings a tendency towards saccharoidal structure is apparent. No dolomitised material was collected.

Frequently, too, blocks of coral, sometimes attaining a diameter of several feet, of Astræa-like species occur included, and in many of these the delicate minute structures are excellently preserved. Occasionally in these fragments traces of recrystallisation are apparent, for on a fractured surface, here and there, fairly large outlines of calcite crystals are often seen. Many of the basalt inclusions are clearly of the

nature of bombs, for these are often associated with distortion of the inclosing laminæ.

Towards the upper surface the ash beds are more homogeneous; there are fewer included fragments, and the rock is finer-grained.

A thin section of this rock discloses fragments of olivine and augite crystals, the former considerably decomposed, inclosed in a fine-grained earthy matrix. Minute pellets of dark volcanic glass, as well as calcareous fragments with traces of organic remains, occur irregularly disseminated.

(B) *The Lava Flows.*

Decomposition of the basalts of the island has produced a rich soil of some depth, which supports a dense thicket vegetation. A considerable area of the island has been cleared. The native gardens are about half-an-acre in extent. On the upper hill slopes, sweet potatoes, yams, and paw-paws are grown, while on the lower slopes, where irrigation is possible, taro, tapioca, bananas, etc., are cultivated. The garden plots are allowed to lie fallow, sometimes for five years. The cleared areas are covered by a luxuriant growth of broad-leafed grass, 3 ft. or more in height.

While a textural variation in the lavas is apparent, there are but slight variations in the mineralogical composition. All the flows are of olivine basalt.

Towards the summit of the island a dark-grey porphyritic rock occurs. The phenocrysts comprise basic felspars (labradorite to bytownite), sparsely developed; augite occurs in large non-pleochroic idiomorphic to subidiomorphic crystals occasionally zoned and twinned. Frequently, in the larger crystals, numerous inclusions occur centrally, and these become less abundant towards the crystal margins. Olivine occurs as small subidiomorphic crystals considerably decomposed peripherally. The groundmass is holocrystalline, consisting largely of felspar microlites, which exhibit fluxion structure, granulites of augite, and more abundant iron ore.

On the crest of Lalor, a reddish-brown rock occurs. The specimen collected was somewhat decomposed. The phenocrysts of this rock include slightly pleochroic crystals of augite, pseudomorphs of iddingsite after olivine, as well as sparsely distributed basic plagioclase crystals. The groundmass is holocrystalline. The rock is extremely scoriaceous in parts.

The north-eastern promontory of the island is composed of a compact, dark-grey, fine-grained rock, containing nodules of olivine, which are considerably decomposed. This flow is overlain by a reddish porphyritic rock having an aphanitic groundmass, and constitutes the cliff-bound headland which is distant a few hundred yards from low-water mark. The olivine phenocrysts in this rock are in many cases

completely replaced by iddingsite; the augite, though fresher, is clouded.

On the north side of the island the ash beds are overlain on the east by a fine-grained dark-grey rock, which, along the plane of junction with the ash beds, is scoriaceous for a few feet. Here, fluidal structure is exhibited in the elongation of the vesicles. Small sills occur intruded along the bedding planes of the ash beds. In this rock, augite phenocrysts occur more abundantly than those of olivine. The latter are rather decomposed.

West of the ash beds, in a grey porphyritic rock, the olivines are, to a great extent, completely replaced by lamellar iddingsite. Augite phenocrysts are somewhat rare. Fluxion structure is exhibited in the orientation of the plagioclase microlites of the groundmass.

The flows which constitute the headlands in southern shore lines are identical in character with the foregoing rocks. The olivine phenocrysts are partly or wholly decomposed. Olivine nodules are of frequent occurrence. Augite crystals occur sometimes abundantly, but generally are somewhat rare. The groundmass is invariably holocrystalline, often exhibiting flow structure, either in the orientation of the felspar microlites or by the occurrence of lenticles in the groundmass. Often the rocks are scoriaceous along junction planes. Frequently vesicular varieties were encountered.

A thin section of a lava inclusion in the ash beds showed this to be a vesicular olivine basalt. The olivine crystals are idiomorphic. Subidiomorphic augites are less abundant. The recent age of the rocks of the island is demonstrated by the occurrence in the ash beds of recent corals, which retain their original structure. While a considerable amount of the material comprising the ash beds has been derived from the disruption and pulverisation of the underlying coralline material, it is improbable that the larger blocks of coral have been ejected from the vent. Rather, it would appear that these have been simply thrown upon the wave-swept slopes of the ash cone, by the action of storms. The horizon upon which these corals were observed closely approximates to the present sea-level. While many of the basalt inclusions are clearly of the nature of bombs, many have a curiously water-worn appearance and are not associated with distortion of the inclosing strata. In the wider bands of the ash beds, current or false bedding is apparent, and this appears to be confirmatory evidence of wave action on the cone slopes. No trace of a vent or plug was observed on the island. The flows appear to dip conformably with the cone slope. During the effusive period the sea-level approximated to the present level, for, on the southern side of the island beach sand, silicified, containing modern sea shells, occurs enveloped in the lava between the present tide levels, while in the north-west a beach rock containing shells (small *Tridacna*

*gigas* amongst them), has been silicified by the overlying lava flows, clearly demonstrating the recent age of the flows.

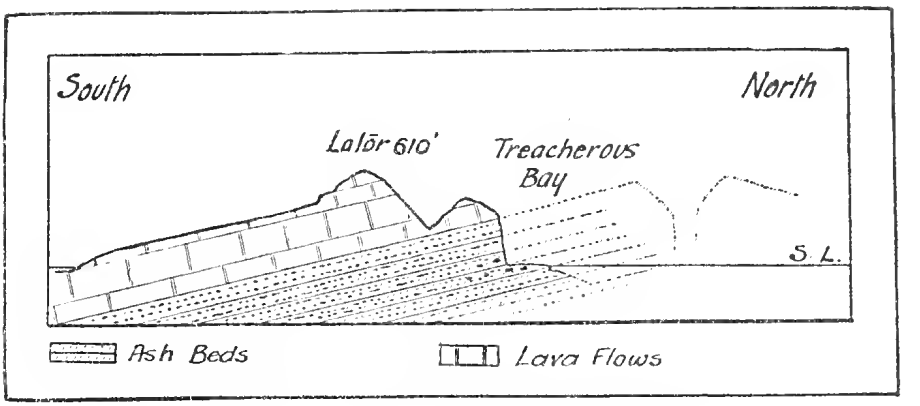
### The Shore Line.

The island has, on the whole, a linear coast line. No deep embayments occur, but there have been certain small indentations now infilled by beach materials. (Plate IX., Fig. 1.) The villages on the southern side of the island are situated on wave-built terraces which attain a maximum width of 100–200 yards. At the heads of the infilled coves, springs generally occur, encircled by gardens. The water-table appears to be about 20 feet above the high-water level on the southern side, and somewhat lower on the northern side, of the island. The village of Moggor, on the south, is situated on a terrace 12 feet above high-water level. All the terraces appear to be of uniform elevation. Streams, fed by the springs at the heads of the coves, meander about in the flats and are entrenched 8 feet–10 feet in the unconsolidated sandy material which contains shells and coral fragments. While one would not be justified in postulating, from this evidence alone, a retreat of the sea-level, confirmatory evidence of such a movement is offered elsewhere on the island. On the northern side, to the west of Treacherous Bay, cliffs which have a juvenile profile retreat from the shore line and are overgrown by vegetation. These are beyond the zone of marine erosion. At the cliff foot, beach material, now being fixed by vegetation, occurs. On the southern side of the island, too, basalt bluffs occur, removed 20 yards from the shore line, fringed in a similar manner by vegetated detrital material.

A prominent feature is the north-east headland of the island, composed of basalt, very much decomposed on the surface. The cliff face, which is juvenile, occurs about 200 yards from low-water mark. Subaerial denudation has not proceeded to such an extent that the contour is smoothed, or is the cliff recession marked. Coral shingle embankments thrown up by the storm of May, 1922, occur along the northern shore of the island. While this material has been thrown right to the cliff foot in Treacherous Bay, to the east, embankments occur with the characteristic sharp crest which these deposits assume, undisturbed. Marine cut cliffs occur some distance to the rear, so that the shingle embankment forms a bulwark, as it were, protecting the old faceted slope. (Plate IX., Fig. 2.) While the location of the shingle bank is governed by the state of the tide at the time of occurrence of the storm, the position of this, relative to the coast-line cliffs in Treacherous Bay and further westward, indicates an emergence of the land relative to the sea. This change is apparent in the case of the basalt bluffs, for the ash beds are relatively unresistant, and by benching the sea has effaced the strand line. Since the hurricane shingles have remained unscattered after two years, despite the storm of 1923, it is clear that the cliffs at the rear of the embankment are beyond the range of marine erosion, even during the occurrence of the largest storms.

A feature of the shore-line topography is the occurrence of benches. The finest development of these occurs where the ash beds outcrop between tide levels in Treacherous Bay, and attain a breadth of 40–50 yards on a horizon about 4 feet below high-water level. On the platform surface, some trace of differential hardness in the coloured strata of the ash beds is visible, for the bench surface here transgresses the bedding planes of the ash beds. In places the cliffs are strongly undercut, demonstrating the active broadening of the bench due to present-day erosion. (Text-figure 3A, and Plate VIII.)

On the southern side of the island the headlands are invariably composed of tongues of basalt; the flows have a very gentle seaward slope. In many cases joint planes are strongly developed parallel to the planes of contact. This gives rise to an extremely flaggy rock. The basalt tongues can be traced for some distance projecting into the sea by long fingers of detrital material. Here, between tide levels, a series of platforms, approximately on a similar horizon to those occurring in the northern shore line, are developed; but, due to the



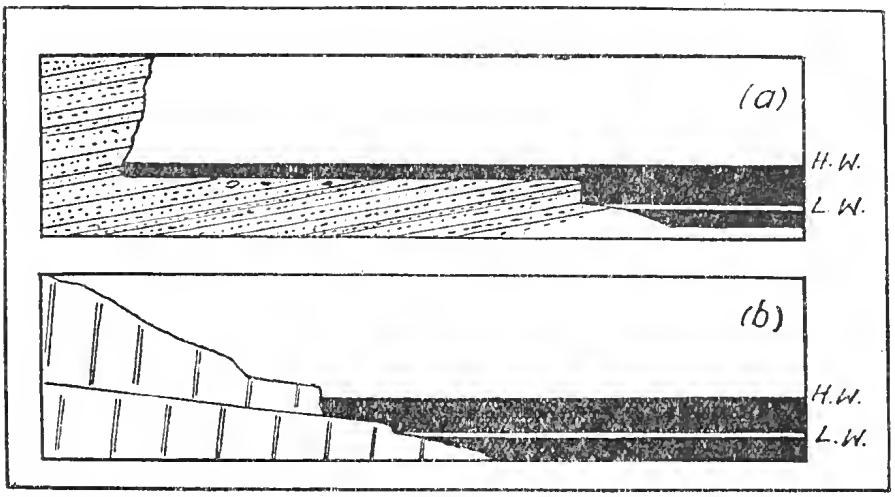

Text-fig. 2.—Diagrammatic North-South Section through Darnley Island.

nature of the rock, the benches are imperfect—some extend for 10–12 yards, but often a mere notch is apparent. (Text-figure 3B.) In certain of the basalt headlands of the southern shore of the island, relics of higher-level benches occur about 10 feet above the level of the modern wave-cut benches. These are much reduced in size but are distinct features. The developments of benches in the basalts of the island occur, either along the gently dipping joint planes or along junction-planes of successive flows. Frequently, along such junction planes the overlying rock for a few feet at the base of the flow is extremely scoriaceous, passing abruptly into the massive variety.

In the ash beds, traces of high-level benches are absent. The high-level benches developed in the flows are of the nature of relics, whose

survival is simply due to the resistance offered by the rock to erosion. Corresponding benches in the tuffs have been effaced. The ash beds are relatively unresistant, and here the coast-line cliffs are retreating under the present-day wave attack.

The benches developed in the ash beds are limited on their seaward side by a small cliff about 5 feet high, which overlooks a narrower bench, which slopes gradually below sea-level. This small cliff is curiously scarred, resembling the vermiculated surface given to rocks by stone-masons. This appearance is due to innumerable excavations made by rock-boring sea urchins. The significance and development of these benches has been discussed by the writer in another paper of this Series




Text-fig. 3.—Benches, Darnley Island. (A) Treacherous Bay (Ash Beds). (B) Southern Shore-line (Olivine Basalt).

of Reports.[3] A recent movement of the sea-level, relative to the land, is clearly demonstrated—a movement of general occurrence along the East Australian seaboard. It was stated by Haddon, Sollas, and Cole:—

> "At present the shores of Torres Strait are apparently stationary; certainly they are not rising. The chief author of this paper has given to the investigation of this subject the pains which its importance would seem to deserve, and is confident that no recent movement of elevation has taken place."

The evidence of shore-line emergence at Darnley Island had been overlooked by Haddon.

[3] The Development and Significance of Benches in the Littoral of Eastern Australia, F. Jardine, Reports G. E. Barrier Reef Com., Vol. 1, No. 13.

Fig. 1.—Ash Beds and Benches, Treacherous Bay. In the Foreground there is a Temporary Accumulation of Debris on the Broad Bench.

Fig. 2.—Scoriaceous Selvage of flow of Olivine Basalt, Western Shore-line.

*Face page* 108.]

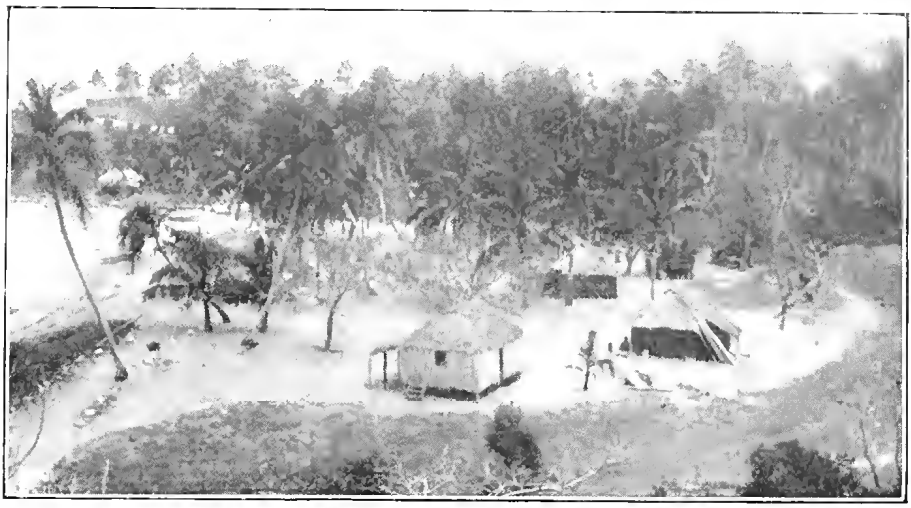


Fig. 1.—Emerged Cove-head Silts (South-west).

Fig. 2.—Coral Shingle Embankment thrown up by the storm of May, 1922, fronting a Vegetated Marine-cut Cliff (North-west).

Fig. 3.—Fish-trap, Darnley Island (Western Shore-line).

*Face page* 108.]

Darnley Island is fringed by numerous fish-traps. To the present natives their origin is legendary. The traps are out of repair, and, as far as can be ascertained, have never been used by the present population for the purpose designed. These traps become uncovered during low-water springs and submerged during the period of high water. Thus their positions relative to the sea-level is probably the same as when constructed. The lowering of the sea-level had therefore occurred previous to the construction of the traps. (Plate IX., Fig. 2.) The writer is indebted to the late Mr. C. Hedley for this latter suggestion.

## DESCRIPTION OF PLATES.

PLATE VIII., FIG. 1.—Ash beds and benches, Treacherous Bay. In the foreground there is a temporary accumulation of débris on the broad bench.

PLATE VIII., FIG. 2.—Scoriaceous selvage of flow of olivine basalt, western shore line.

PLATE IX., FIG. 1.—Emerged cove-head silts (south-west).

PLATE IX., FIG. 2.—Coral shingle embankment thrown up by the storm of May, 1922, fronting a vegetated marine-cut cliff (north-west).

PLATE IX., FIG. 3.—Fish-trap, Darnley Island (western shore line).

REPORTS OF
GREAT BARRIER REEF COMMITTEE

VOL. II, No. 9.

# The Divergence of the Ends of the Great Barrier Reef from the Coast.

By

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Surgeon Lieutenant Commander, R.A.N.

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No. 9.

## THE DIVERGENCE OF THE ENDS OF THE GREAT BARRIER REEF FROM THE COAST.

By W. E. J. Paradice, M.B., Ch.M., Surgeon Lieutenant Commander, R.A.N.

On glancing at a map we notice that the Great Barrier Reef diverges from the coast of Queensland as we work south, until it reaches Swain Reefs, after which it turns inwards, is broken by Capricorn Channel, and ends as a number of detached reefs and islands meeting the coast at Great Sandy Island. There is also a less-marked divergence of the extreme northern end of the reef from the coast.

From the study of sections we notice a less obvious feature—namely, that as the reef works eastwards, widening its distance from the mainland, the slope from the outer edge down into the deep water of the Pacific becomes less steep.

From 12 degrees south to 17 degrees south the outer edge of the reef runs almost parallel to the general line of the coast at about 40 miles distance, what variations in distance there are being due to bays and capes. In this area the slope outside the barrier is very steep indeed. South of this area it can be seen from sections that the outer slope is much more gradual.

Have the rivers of the mainland been the cause of this?

In the 12 degrees–17 degrees section we have no very large river, the Kennedy and Normanby being the largest. These lose their force and deposit their silt in Princess Charlotte Bay, thus having little influence on the reef.

South of 17 degrees south we have the Burdekin and Fitzroy, both large rivers flowing into bays much smaller than Princess Charlotte Bay and consequently exerting much less influence on the river current with its silt.

These rivers may have some influence both in causing (1) more gradual descent to the east and (2) the reef to grow at a further distance from the shore.

The Fitzroy River seems to have scoured out a large basin from 40 to 50 fathoms in depth, north-east from its mouth, and it looks as if its muddy water has kept this basin clear of coral until we reach Swain Reef. This basin is seen between 151 degrees east and 152 degrees east in sections in the region of 22 degrees south, and it empties into the Pacific through a wide, deep canal, the Capricorn Channel.

In a previous communication[1] I mentioned the apparent influence of currents in shaping individual reefs, and now I am inclined to think that currents have had an influence over the general shape of the whole Great Barrier Reef.

In the extreme north the Great Barrier Reef works away from the mainland, being carried to the east presumably by the currents of Torres Strait.

The current probably produces this result by firstly carrying out and depositing sand, eventually making the water shallow enough for reef-building corals to exist, and secondly by carrying the reef-building polyps out into the area which it has rendered shallow.

To summarise, we might say that the Great Barrier Reef runs parallel to the Queensland coast except where it is carried eastward, in the extreme north by the currents of Torres Strait, and in the extreme south by the influence of the Fitzroy and perhaps the Burdekin River.

Has the temperature of the water anything to do with the difference of slope outside the barrier in the north and south?

In the north, where the water is warmer, we can reasonably assume that coral will grow more rapidly than in the cooler water of the south.

Now having had the coral polyps carried to various positions, in the north there will be a healthy rapid growth, giving the almost vertical outer slope of the Great Barrier Reef, and in the south there will be a slower, probably less healthy and less resistant growth, which will be spread over a greater area by the currents acting during its longer period of growth, giving individual reefs which do not descend so rapidly into deep water and giving the whole southern end of the Great Barrier its more gradual easterly slope.

The recent boring operations at Michaelmas Reef where coral was found to be supported by estuarine sand extending to the full depth of the bore (600 feet), seems to support the assumption that the conformation of the Great Barrier Reef is at least to some degree influenced by the silt brought down by the rivers existing at the time of the formation of its various components.

The above observations are offered as a possible explanation of this divergence and of the increasingly more gradual slope from the summit seawards as we work south.

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[1] "The Pinnacle or Mushroom-shaped Coral Growths in Connection with the Reefs of the Outer Barrier," these reports, vol. I., pp. 52-66.